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CONTENTS

	PAGE
SOME PRACTICAL ASPECTS OF MILK HYGIENE ..... *By C. S. Bryan*	251
FIELD TESTS WITH SEED SAVER DUST IN CONTROL OF STINKING SMUT OF WHEAT ..... *By J. H. Muncie*	258
COST AND RETURN FACTORS IN DAIRY PRODUCTION IN 1946 ..... *By E. H. Carter, and W. H. Vincent*	261
A NON-TOXIC PLASTIC COATING TO IMPROVE THE KEEPING QUALITY OF CUT FOLIAGE *By C. L. Hamner, J. B. Gartner, and F. L. O'Rourke*	268
LENGTHENING THE LIFE OF CUT FLOWERS AND FLORAL GREENS BY THE USE OF PLASTIC COATINGS ... *By C. H. Sherwood, and C. L. Hamner*	272
SOME STUDIES ON TEMPERATURE ADAPTATION IN THE BABY PIG ..... *By D. P. Wallach, H. W. Newland, and W. N. McMillen*	277
RED CEDAR-APPLE AND HAWTHORN RUST DISEASE CONTROL BY SPRAYING RED CEDARS IN THE SPRING ..... *By Forrest C. Strong*	283

(Continued on Next Page)

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V. R. GARDNER, Director - - - - - - - - - *J. G. DUNCAN, Editor*

THE QUARTERLY BULLETIN

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents: (1) progress reports on long-term major research projects; (2) final reports on short-term projects and (3) short, timely articles of a popular nature that bring together information from various sources on subjects in which farmers are interested.

CONTENTS

(Continued from Outside Front Cover)

PAGE

THE EFFECT OF BUFFERS ON THE GROWTH-INHIBITING PROPERTIES OF SODIUM 2,4-DICHLOROPHENOXYACETATE
By E. H. Lucas, Irma M. Felber, C. L. Hamner, and H. M. Sell 289

INSECTICIDES INCREASE LEGUME SEED *By C. E. Pederson* 298

THE CHEMICAL CONTROL OF GRAIN WINDBREAK ROWS IN MUCK CROPS
By Clarence M. Hansen, Keith C. Barrons, and George W. French 309

TAX VARIATION IN OAKLAND CO. AND TREND TOWARD EQUALIZATION OF TAXES BY MEANS OF ENLARGED SCHOOL DISTRICTS
By J. F. Thaden 317

PROTECTION OF VEGETATION FROM FROST DAMAGE BY USE OF RADIANT ENERGY, PART III
By F. J. Hassler, C. M. Hansen, and A. W. Farrall 339

BULLETIN REVIEWS 361

JOURNAL ARTICLE ABSTRACTS 362

SOME PRACTICAL ASPECTS OF MILK HYGIENE

By C. S. BRYAN
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MANY PROFESSIONS are vitally interested in and concerned with the sanitary production, processing and distribution of a safe milk for the consuming public. All members of those professions must have a wide perspective of the ultimate goal in order that each may best integrate his efforts with the others for insuring the best milk for all. To accomplish this end, the members of those professions must be ready to advise dairymen accurately concerning all phases of dairy hygiene. Above all, if the farmer is to apply successfully the sanitary procedures recommended to him they must be economically sound. Some practical aspects of milk hygiene are herein presented.

A CITY MILK SUPPLY

The overall picture of a city milk supply is complex, but an understanding of its various aspects is essential if one is to comprehend the far-reaching effects of any advice in milk hygiene given a dairyman. The milk picture for the city of Lansing, Michigan, with a population of almost 100,000 will illustrate a typical setup:

10,000 cows producing the milk on
1,000 farms with
45 haulers conveying the milk to the
10 city milk plants where it is processed, and delivered to the consumer by
120 wagons and trucks (100 retail, 20 wholesale)

THE ESSENTIALS OF CLEAN AND SAFE MILK PRODUCTION

The health of the cows and the methods of caring for the cows, the utensils, and the milk on the farm determine the type of milk that is produced. The need for adequate barn and milkhouse facilities and

ARTICLE 30-35

TABLE 1—*The bacteria count of milk produced by healthy and diseased cows. Samples collected aseptically from the cows*

Udder infection	Bacteria per cc. of milk	
	Percent with fewer than 1,000	Percent with more than 1,000
None	95	5
Brucella	76	24
Streptococcus	30	70
Staphylococcus	25	75
Coliform	15	85

dairy equipment is recognized, so no data are presented on these subjects. An appreciation of the influence of each essential item upon the quality of the milk will stimulate the correction of conditions, where needed, to make possible the production of good and safe milk.

1. **Clean and Healthy Cows**—The health of the dairy cow is the keystone of a safe milk supply of high quality. The fitness of cattle to produce such milk is determined by their freedom from disease. Under no circumstance should the milk be used if the cattle are obviously suffering from any disease. The data in Table 1 reveal the influence of udder infection on the quality of milk produced, for in each case of udder infection the percentage of cattle producing milk with a bacteria count of over 1,000 increases greatly.

The influence of cleanliness of the cow on the bacteriological quality of the milk produced is presented in Table 2. These results indicate the value either (a) of clipping the long hair on the udder and rear quarters several times a year, by reducing the number of bacteria per cc. from 20,000 to 5,000, or (b) of disinfecting the udder and teats

TABLE 2—*The bacteriological condition of the milk produced by hand milking of apparently clean, healthy cows under varying management conditions (A chlorine solution of 300 parts per million of available chlorine used for disinfection)*

Management condition		Bacteria per cc. of milk
Hair on udder and rear quarters	Disinfection of udder and teats	
Not clipped	None	20,000
Not clipped	Yes	6,800
Clipped	None	5,000
Clipped	Yes	550

prior to each milking in maintaining the high quality of milk, indicated by the bacteria count of 6,800, as it is obtained from the healthy cow. Best results were obtained when both clipping and disinfecting were done, for here the bacteria count of milk produced was only 550. The necessity for having clean premises—such as lots, lanes, etc.—and the value of barns that are clean and well bedded, are obvious in quality milk production.

2. **Clean and Healthy Handlers**—The clothes of the handlers should be clean, especially during the milking process, so as to preclude the possibility of them ever becoming a source of contamination. Since the hands have a more intimate contact with milk a study of their influence is indicated. An opportunity presented itself to study the bacteria count of milk produced by hand milking under various conditions; the results are presented in Table 3. In all cases only clean and sanitized utensils were used to handle the milk, thus reducing to a minimum the bacterial contamination from this source.

The bacteria count of milk collected aseptically was normal for healthy cows, being 300 and 400 respectively for the two groups of cows. The dry brushing of udders prior to milking was not enough to prevent dandruff and some other debris with bacteria from falling into the milk as revealed by the 16,000 count of milk from the apparently clean cows and 350,000 from the obviously dirty cows. Wiping with water alone removed some of the gross dirt, but the bacteria count of milk obtained was higher, 56,000 for the clean and 425,000 for the dirty cows, than when only dry brushing preceded the hand-milking process. Disinfection of the udders and teats, although not perfect, resulted in the production of milk with a very low bacteria count; 700 by the clean and 1,500 for the dirty cows. The value of

TABLE 3—*The bacteria count of milk produced by the hand milking of healthy cows (whose udders had been clipped) that were either reasonably clean or reasonably dirty when the udders and teats were either dry, wiped with water only, or disinfected (solution of 300 p.p.m. available chlorine or 1 to 1,000 quaternary ammonium solution)*

Appearance of rear quarters and udders of cows	Bacteria per cc. of milk produced			
	Collected aseptically from cow	After dry brushing	After wiping with water	After disinfection
Reasonably clean	300	16,000	56,000	700
Reasonably dirty	400	350,000	425,000	1,500

TABLE 4—*Number of bacteria on dairy utensils*

Farm	Equipment rinsed with 500 cc. of sterile water	Bacteria on equipment	
		Utensils ready for use as found on the farm	Utensils sanitized with chlorine
1	1 pail and 1 strainer	28,000,000	1,500
2	1 pail and 1 strainer	700,000	500
3	1 pail and 1 strainer	2,000	1,000

clipping and disinfection is obvious from these results. A study of milk-borne disease outbreaks reveals the importance of health of the dairy worker.

3. **Clean and Sanitized Utensils**—Improperly cleaned and sanitized utensils may be the sources of many bacteria and may easily transform a high-quality milk to an inferior or even an unacceptable product. To demonstrate the value of proper cleaning and sanitization, rinse counts were made of utensils ready for use as found on the farm. A few days later an unannounced visit was made to each farm. This time the utensils were sanitized with a chlorine solution (50 p.p.m.), allowed to drain for 30 minutes, and were then rinsed with sterile sodium thiosulfate water to inactivate the remaining chlorine. Bacteria counts were made of all of these rinsings to determine the number of bacteria removed by the water (Table 4). Normally these bacteria get into the milk as the utensils are used during the milking process. These data are convincing evidence of the value of sanitization of all dairy utensils, especially those on the farm. **Clean** utensils have very few bacteria on their surfaces and, therefore, will not contribute many bacteria to the milk handled therein.

4. **Prompt and Efficient Cooling**—Milk is a good food for bacteria as well as for man and other animals. As it comes from the cow it is at a temperature ideal for multiplication of the bacteria that gain access to the milk. According to the data in Table 5, the practical procedure for dealing with these bacteria is to cool the milk immediately to 50° F. or lower and to hold it at that point until it goes to the receiving station.

5. **An Adequate Water Supply That Is Both Satisfactory and Safe**—Dairy animals need a constant supply of clean and fresh drinking

TABLE 5—*Bacteria counts of milk obtained upon the storage of milk at different temperatures for varying periods of time when cooled to those temperatures immediately after production*

Period of storage	Bacteria count of the milk							
	Original count 5,000				Original count 100,000			
	Temperature of immediate cooling and storage of milk							
	40° F.	50° F.	60° F.	70° F.	40° F.	50° F.	60° F.	70° F.
5 hours....	5,000	5,000	5,000	7,500	100,000	100,000	100,000	340,000
10 hours....	5,000	5,000	6,000	28,000	100,000	100,000	180,000	870,000
15 hours....	5,000	5,000	12,000	200,000	100,000	150,000	300,000	2,000,000

water if they are to produce at a maximum. A similar water supply is essential for the proper cleaning of dairy utensils and for the cooling and storage of milk. Occasionally the water supply, used for these purposes, becomes contaminated with specific types of bacteria that produce undesirable changes in the milk besides being objectionable merely because of their presence. The ropy milk bacteria come under this category.

A review of two experiences will direct our attention to some of the aspects of overcoming the ropy milk problem. An outbreak of ropy milk presents the following two characteristics: 1) The milk is normal in physical appearance as it is obtained from the cows, and 2) A tenacity of the contaminated milk, and especially the cream, develops within 12 hours if the milk is not properly cooled. Several organisms, including some of the coliform group, are capable of causing ropy milk but the main one is *Alcaligenes viscosum*. The original source is not always known, but stagnant water in the barnyard or pasture should be immediately suspected, while the immediate source is usually the coat of the cow or surface water that gains entrance to the well water.

In one case studied the milk apparently became contaminated, during milking, from the exterior of the cow. The cows were immediately prevented from gaining access to stagnant water in the pasture where they had gone to keep cool during the summer heat, but the ropy milk trouble continued. A thorough check-up revealed that the farmer always rinsed the stirring rod in the cooling tank between cans

and between milkings. Thus the cooling tank water was inoculated from the contaminated milk on the stirrer. As a result of this insanitary practice the cooling tank water became heavily inoculated and, through the stirring rod, became the immediate source of subsequent contamination of the daily milk. A thorough cleansing and disinfection of the cooling tank and discontinuance of the practice of rinsing the stirring rod in the cooling water overcame the difficulty on this farm.

The second case was very similar insofar as the original source and its elimination were concerned. It was dissimilar in that the farmer did not rinse the stirrer in the cooling tank water, yet ropiness appeared rather consistently by morning in his night's milk. The contaminated area was in the poorly drained barnyard. On this farm the milkhouse was situated directly over the well which was the source of water used for washing and rinsing equipment and for the cooling of the milk. The concrete cover of the well, which was also the floor of the milkhouse, had a crack in it so that water from the milkhouse could seep back into the well. Apparently the milkhouse floor became inoculated with ropy milk bacteria from the farmer's shoes. This inoculum had an opportunity to build up in the well by the daily addition of contaminated water from the floor. Since no chemical sanitizer was used as a final treatment of dairy utensils on this farm and since the dairy detergent did not inactivate the ropy milk organisms the utensils were always contaminated and served to inoculate the milk. To overcome the chain of contamination, a new well cover was installed. The working surfaces of the milkhouse and cooling tank were thoroughly cleaned and then disinfected with a chlorine solution. A strong chlorine solution was prepared (1 pound of chlorine powder containing 15 percent available chlorine was dissolved in 5 gallons of water) and placed into the well. After one hour the pump was run for 15 minutes to draw this water through the pump and pipes. Apparently this served to destroy the ropy milk bacteria because none could be recovered from the water after this treatment, and no more ropy milk troubles were experienced.

SUMMARY

Application of these five essentials to milk production will go a long way towards realizing a safe milk of high quality:

1. Clean and healthy cows.
2. Clean and healthy handlers.
3. Clean and sanitized dairy utensils.
4. Prompt and efficient cooling.
5. An adequate water supply that is both satisfactory and safe.

FIELD TESTS WITH SEED SAVER DUST IN CONTROL OF STINKING SMUT OF WHEAT

By J. H. MUNCIE
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AT VARIOUS TIMES since 1930, the Section of Botany and Plant Pathology has carried on tests of fungicides as seed treatments for combatting stinking smut or bunt of wheat.

In August 1946, the Parsons Chemical Works submitted a sample of their "Seed Saver Dust" for tests on control of stinking smut. A series of plots of smutted wheat (variety Bald Rock), treated with (a) this material and (b) with New Improved Ceresan-treated and untreated smutted wheat seed as checks were planted in Field 19 on October 26, 1946.

DOSAGE OF STINKING SMUT SPORES

In tests of this type a standard procedure (1) is followed, in which smut spores sifted through an 80-mesh screen are applied to the clean wheat seed before the disinfectant treatment is made. In these tests spores at the rate of 1 part by weight to 200 parts of untreated clean wheat were applied as the standard dosage. Smut spores and wheat were thoroughly mixed mechanically until the wheat kernels were distinctly darkened by the adhering inoculum.

DOSAGE OF DISINFECTANT

The dosage of disinfectant used was that recommended by the manufacturer of the disinfectant, namely ½ ounce disinfectant to one bushel of wheat. The disinfectant was thoroughly mixed with the smutted wheat in a glass container by shaking and rotation. Examination of the treated wheat showed disinfectant coating each kernel more or less completely.

ARTICLE 30-36

LAY-OUT OF PLOTS

The plots were laid out in 8-foot rows as follows:

Plot 1	Parsons Seed Saver	5 rows
2	Check (smutted wheat)	5 rows
3	Ceresan	5 rows
4	Parsons Seed Saver	5 rows
5	Check (smutted wheat)	5 rows
6	Ceresan	5 rows
7	Parsons Seed Saver	10 rows

The wheat was planted by hand 24 hours after the disinfectant was applied to the smutted seed. The disinfected seed of each material was planted separately and the untreated smutted seed planted last.

RESULTS OF SEED TREATMENT TESTS

Counts were made of the smutted and clean wheat heads on the three center rows of each plot on August 8, 1947. Results of these counts are given in the following table:

	Treatment	Number wheat heads counted			Percentage with smut
		Clean	Stinking smut	Total	
1	Parsons Seed Saver	195	45	250	18.0
2	Untreated check	93	79	172	45.9
3	New Improved Ceresan	65	0	65	0.0
4	Parsons Seed Saver	82	12	94	12.7
5	Untreated check	80	31	111	27.9
6	New Improved Ceresan	108	4	112	3.6
7	Parsons Seed Saver	53	24	77	31.2

Results of these tests show that the average percentage of bunt or stinking smut for the treatments was as follows:

Untreated smutted check	38.80 percent
Parsons Seed Saver Dust	19.24 percent
New Improved Ceresan	2.26 percent

DISCUSSION

Although heavy stinking smut infection of wheat is not a common occurrence in Michigan, the writer has examined fields in which infection ranged from 10 to 60 percent. The average percentage in-

fection on the untreated smutted check plots is not unduly high. Temperature, moisture, strain of the stinking smut fungus and relative susceptibility of the wheat all enter into the results of a field test of this type. In this case there was a decided lack of soil moisture after the plots were planted, which probably lessened spore germination and resulting infection.

CONCLUSIONS

It is obvious from these tests that Parsons Seed Saver Dust applied at the rate of ½ ounce per bushel gave decidedly inferior control of stinking smut, as compared with New Improved Ceresan used at the same rate of application. Under similar conditions of natural heavy infection of the seed, Parsons Seed Saver would be entirely inadequate in controlling stinking smut or bunt.

LITERATURE CITED

(1) Lenkel, R. W. Studies on Bunt, or Stinking Smut, of Wheat and Its Control. U. S. Dept. Agri. Tech. Bul. 582. 1937

COST AND RETURN FACTORS IN DAIRY PRODUCTION IN 1946

By E. H. CARTER and W. H. VINCENT
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PRODUCTION COSTS on individual herds varied from $2.84 to $9.68 per 100 pounds of milk in 1946 in the Detroit milkshed. Why did it cost some dairymen 3 to 4 times as much to produce milk as it did other dairymen? A dairy cost study, cooperative between the Michigan Milk Producers Association and the Farm Management Section, has helped to provide the answer to this question.

Average production per cow, butterfat test, size of herd, labor requirements, feed requirements, and major costs and returns for the

TABLE 1—*Milk production cost and income per 100 pounds, southeastern Michigan, 1945-46*

Item	1945	1946
Number of cooperators	105	95
Milk production per cow (lb.)	8,250	8,190
Butterfat production per cow (lb.)	303	303
Butterfat test (%)	3.67	3.71
Cows per herd	17	16
Hours labor per cow for year	132	132
FEED FED PER COW IN YEAR		
Concentrates (lb.)	3,250	2,840
Hay (lb.)	4,170	4,340
Silage (lb.)	4,400	5,080
Other roughage (lb.)	170	500
Pasture (days)	139	149
COSTS PER 100 POUNDS MILK		
Feed	$1.79	$1.97
Labor	1.19	1.35
All other items*	.80	.84
Total	$3.78	$4.16
INCOME PER 100 POUNDS MILK		
Milk sold and used	$3.24	$4.08
Other credits	.66	.31
Total	$3.90	$4.39
NET RETURN PER 100 POUNDS MILK	$0.12	$0.23

*Include cow depreciation, interest on cows, building and equipment use, breeding, bedding, electricity, veterinary, miscellaneous cash expenses, and an estimated share of such general expenses as auto, telephone, etc.

ARTICLE 30-37

first 2 years of the study are shown in Table 1. Coincidentally, the average figures for labor requirements and butterfat production are identical for 1945 and 1946. Averages for milk production, butterfat test and size of herd were about the same for the 2 years. As for feed costs, the value of the feed was entered at farm price if produced on the farm, and at actual cost if purchased. Hired labor was entered at actual cost. The cooperator entered what he thought a fair charge for both his time and time spent by the family in the dairy business. "Other" income consisted of calves, manure, and subsidy payments.

PRODUCTION PER COW

Variations in Production—Average butterfat production a cow per herd basis for individual herds in this study varied from 212 to 408 pounds in 1946. Annual milk production per cow averaged 8,190 pounds and ranged from 5,300 to 11,420 pounds. About 15 percent of the herds produced annually less than 250 pounds of butterfat, and about 15 percent produced more than 350 pounds of butterfat per cow (Table 2). This variation in production is largely explained by influences within the control of the individual farmer.

Feed Fed Per Cow—Cows in herds averaging over 350 pounds of butterfat consumed about 50 percent more concentrates, 10 percent more barn-fed roughages and about the same pasture as the cows in herds averaging less than 250 pounds of butterfat. The additional feeding resulted in a $37 higher feed cost per cow, but higher production made a 12-cent less feed cost per pound of butterfat and a 20-cent less cost per hundredweight of milk produced.

Labor Costs and Returns—In this study the total cost of labor was 22 percent higher in the herds averaging more than 350 pounds of butterfat than in the herds averaging less than 250 pounds of butterfat per cow. This is due to 10 percent more hours spent and a 12-percent higher labor rate in the high-producing herds. However, the effect of labor rate is less pronounced when herds with butterfat yields above and below 300 pounds per cow are compared. In this comparison the higher producing group required 10 percent more hours per cow, but the hourly labor rate was only 6 percent more than the lower producing group. Thus, it was seen that both quantity and quality of labor (as indicated by rate) varied among different production levels.

Increased returns per cow more than compensated for the additional costs apparently necessary for higher production. Although the

labor cost per cow was $22 more in the 15 high-producing herds than in the 14 low-producing herds, the labor cost per pound of butterfat was 9 cents less and per hundred pounds of milk produced was 19 cents less in the high-producing herds.

The herds producing less than 250 pounds of butterfat had low average costs per cow but returns lacked $1.13 per cow of paying all costs. The herds averaging over 350 pounds of butterfat paid all costs and had $34 per cow to spare. The return an hour of operator's labor for the high- and low-producing herds was $1.34 and 93 cents, respectively. Thus, in terms of returns, the operator's time had a 41-cent an hour higher value on the farms with higher dairy production. These figures show rather definitely the positive relationship of high returns to high production.

TABLE 2.—*Production per cow and its influence in dairy costs and returns in southeastern Michigan, 1946*

Item	Pounds butterfat produced per cow				
	Under 250	250-299	300-349	Over 350	All herds
Number of herds	14	30	36	15	95
Number of cows per herd	16	16	16	17	16
Butterfat production per cow	232	281	323	367	303
Milk production per cow	6,510	7,760	8,760	9,150	8,190
Butterfat test (calculated)	3.56	3.62	3.69	4.01	3.71
FEED FED PER COW					
Concentrates (lb.)	2,253	2,940	3,037	3,334	2,840
Hay (T.)	2.3	2.2	2.1	2.2	2.2
Silage (T.)	1.6	3.0	2.7	2.2	2.5
Other roughage (lb.)	614	540	429	296	503
Pasture (days)	165	142	143	162	149
Labor hours, total per cow	111	130	147	122	132
Labor hours by operator per cow	92	88	92	110	94
COSTS PER COW*					
Feed	$136.02	$159.14	$168.05	$173.15	$161.45
Labor	98.05	104.15	115.35	120.33	110.20
Depreciation	.....	2.87	5.83	10.77	4.27
Other items	53.80	58.79	65.84	80.47	64.30
Total	$287.87	$324.95	$355.07	$384.72	$340.22
INCOME PER COW					
Milk sold and used	257.53	312.11	354.56	393.31	333.63
Subsidy	10.21	10.06	10.92	8.52	10.16
Calves at 5 days	7.37	5.86	8.28	8.63	7.47
Manure	7.55	9.62	8.00	8.13	8.45
Appreciation	4.08	.....	.....	.....	.....
Total	$286.74	$337.65	$381.76	$418.59	$359.71
Net return per cow	−1.13	12.70	26.69	33.87	19.49
Total cost per pound of butterfat	1.25	1.17	1.11	1.06	1.12
Income per pound of butterfat	1.25	1.21	1.19	1.15	1.18

*Costs include feed at farm prices, labor at an average of 83 cents an hour, and all other items at current prices.

SIZE OF HERD

Variations in Size of Herd—The range in number of cows per herd in the herds studied in 1946 was from 6 to 37. Approximately 50 percent of the dairymen had herds smaller than 15 cows and the most common herd size was 12 cows.

The greatest effects from variation in herd size were on the labor hours per cow, labor rate, and barn and equipment costs per cow. Little effect was noticed on average butterfat production per cow or breeding costs per cow. Feed costs were higher on herds with 25 or more cows, probably because of the somewhat higher milk and butterfat production of these herds.

Labor Requirements—The labor requirement per cow was especially affected by size of herd. An average of 68 hours was spent per cow in herds consisting of 25 or more cows, or 58 percent less than in the herds smaller than 10 cows. Although the average hourly labor charge made by the farmer was 24 cents higher for the large herds, the superior labor efficiency on these farms resulted in a saving of $18 per cow in labor costs. In other words, the time spent on each cow in the large herds was enough less to more than pay for labor of higher charge per hour.

Labor Rate—The differences in the labor rate in various size herds is probably explained by the extent that dairying dominated the operator's interests. It is likely that herds smaller than 10 cows supplemented some other farm enterprise, and that herds larger than 25 cows constituted the major enterprise of those farms. To this extent, the value given labor varied among herds of different size. The average labor rate was also affected by the extent that labor besides that of the operator was used. The amount of hired and family hours spent per cow increased steadily from 19 percent of total labor in herds smaller than 10 cows to 43 percent of total labor in herds having more than 25 cows. The value of hired and family labor increased with its need. The average charge for hired and family labor varied from 47 cents an hour in the smallest herds to 63 cents an hour in the largest herds.

Building and Equipment Use—The investment per cow and the cost of using buildings and equipment per cow was highest in the herds smaller than 10 cows and steadily decreased in larger herds except those larger than 25 cows (Table 3). It is possible that the 10

TABLE 3—*Size of herd and its influence on cost and returns, southeastern Michigan, 1946*

Item	Average number of cows per herd					
	Under 9.9	10-14.9	15-19.9	20-24.9	25 and over	All herds
Number of herds	17	30	24	14	10	95
Average number cows per herd	8	12	18	22	31	16
PRODUCTION PER COW						
Milk (lb.)	7,390	7,980	8,110	8,110	8,960	8,190
Butterfat (lb.)	298	297	298	312	316	303
LABOR						
Total hours per cow	185	133	133	123	117	132
Operator hours per cow	151	104	101	74	67	94
Charge per hour (all labor)	$ 0.66	$ 0.85	$ 0.87	$ 0.81	$ 0.90	$ 0.83
Operator charge per hour	.71	.94	.95	.96	1.10	.94
INVESTMENT PER COW						
Barn	292.00	232.00	152.00	123.00	214.00	190.00
Equipment	33.00	30.00	28.00	18.00	27.00	27.00
COSTS PER COW						
Feed	147.12	157.61	161.36	160.10	173.78	161.45
Labor	123.11	112.85	115.38	99.54	105.02	110.20
Depreciation (net)	2.01	2.60	6.65	3.23	6.41	4.27
Building use	13.92	10.36	8.30	6.65	11.47	9.58
Equipment use	8.45	6.87	6.52	4.59	5.82	6.25
Breeding costs	9.09	10.89	9.99	9.20	8.72	9.72
Other items	38.09	37.90	37.23	38.10	42.79	38.75
Total	$341.79	$339.08	$345.43	$321.41	$354.01	$340.22
INCOME PER COW						
Milk sold and used	311.31	328.59	326.95	333.91	358.39	333.63
Subsidy	9.74	9.94	10.64	10.00	10.13	10.16
Calf value at 5 days	8.52	6.77	7.28	8.06	7.51	7.47
Manure	11.35	9.25	8.66	6.55	7.82	8.45
Total	$340.92	$354.55	$353.53	$358.52	$383.85	$359.71
RETURNS						
Net return per cow	0.87	15.47	8.10	37.11	29.84	19.49
Per hour (all labor)	.66	.97	.93	1.11	1.15	.98
Per hour operator labor	.70	1.09	1.03	1.46	1.55	1.14

herds with more than 25 cows were less efficient in the use of equipment and additional building space or used more elaborate and expensive barns and equipment.

Costs and Returns—The herds smaller than 10 cows failed by 87 cents a cow of paying all costs, while the herds larger than 25 cows paid all cost and left about $30 a cow to spare. The hourly labor return was 49 cents higher in the large herds than in the small herds. Respectively, these returns were $1.15 and 66 cents an hour for all labor: when labor returns for the herds were compared, they were about $3,000 higher in the 31-cow herds than in the herds averaging 8 cows. This includes payment for all labor including hired, family and operator's labor. Thus, operators of the large herds in this study used their resources more efficiently and realized higher returns.

LABOR EFFICIENCY

Labor hours per cow varied widely and, for the most efficient fifth of the farmers, amounted to less than half as much as in the case of the least efficient fifth (Table 4). The efficient use of labor reduced costs.

The 19 low-hour dairymen averaged 92 hours per cow as compared with 204 for the 19 high-hour dairymen. Labor cost per cow averaged $90 for the low-hour group and $143 for the high-hour group. The more efficient operators charged more for their time. Labor cost per 100 pounds of milk averaged $1.12 for the low-hour group as compared with $1.64 for the high-hour group.

Total costs per cow for the two groups were $328 and $405, respectively. Labor cost amounted to only 27 percent of total costs for the most efficient group, even though the operators charged more for their time, as compared with 35 percent for the least efficient group. Operator labor comprised 94 percent of total labor costs for the low-hour dairymen as compared to 70 percent for the high-hour dairymen. The tendency for high-labor efficiency to be associated with a high proportion of operator labor costs is also shown in the other groupings.

The return per hour of labor was $1.34 for the dairymen averaging 92 hours a cow as compared with 63 cents for those dairymen averaging 204 hours a cow. Similarly, the net return per cow (after deducting labor costs) amounted to $33 for the most efficient group, whereas the least efficient group lacked $14 of paying costs.

Production per cow did not vary greatly within the groupings. It was, however, slightly higher for the dairymen spending the most time (8,730 pounds of milk compared with 8,020 pounds for the most efficient dairymen). Thus, in spite of higher production, returns an hour were less for this high-hour group. According to Table 4, the more efficient dairymen tended to have herds of about 17 to 19 cows as compared with 13 for the less efficient dairymen. Apparently 17 to 19 cows are required for an efficient unit of operation.

Inasmuch as high labor efficiency was associated with lower costs, an attempt was made to discover why some farmers did the job in less time than did others. The more efficient dairymen apparently did a more thorough job of planning barn arrangement and chores and of using labor-saving equipment, as evidenced by a comparison of certain chore practices. "Managed" milking, at least in part, was practiced

TABLE 4—*Relation of labor efficiency to costs and returns, 1946*

Item	Hours labor per cow					
	79-108	109-120	121-136	137-166	167-437	All herds
Number of herds	19	19	19	19	19	95
Cows per herd	19	17	20	13	13	16
Labor hours per cow	92	114	127	150	204	132
B.F. production per cow (lb.)	302	298	304	291	328	303
Milk production per cow (lb.)	8,020	7,900	8,250	8,160	8,730	8,190
COSTS PER COW						
Labor	$ 90.06	$101.90	$108.81	$119.53	$142.85	$110.20
Total	328.08	323.85	336.93	340.87	404.96	340.21
LABOR COSTS						
Percent of total cost	27	31	32	35	35	32
Percent operator's labor	94	86	70	80	70	80
Average labor rate of oper.*	$ 0.99	$ 0.95	$ 0.92	$ 0.95	$ 0.80	$ 0.94
Labor cost per cwt. of milk	1.12	1.29	1.32	1.46	1.64	1.35
RETURN, HOUR LABOR	1.34	1.15	1.02	0.92	0.63	0.98
NET RETURN PER COW	33.19	29.14	21.51	17.95	−14.50	19.50

*Simple average.

by 58 percent of the operators spending less time as compared with 37 percent of the operators spending more time. There was a tendency for the low-hour farmers to use grain and silage carts in feeding. There was also a tendency for the low-hour dairymen to use litter carriers rather than wheelbarrows or to fork the manure from the stable by hand.

The breed of cows was not associated with labor efficiency. Length of pasture season was not a prime factor in determining labor efficiency. In fact, study indicated that the high-hour dairy farmers had their cows on pasture a month longer than did the low-hour dairy farmers.

This study indicates that labor requirement per cow can, in some cases, be reduced by as much as 50 percent. The amount of labor required can be reduced by better chore planning, the adoption of labor-saving equipment, and a more convenient arrangement of the barn.* In some cases, more cows should be added to the herd to effect an efficient unit of operation, as previously discussed. By decreasing labor costs, it would be possible for some dairymen to realize as much as 70 cents more an hour for labor spent in the dairy enterprise.

*For further information, see *Reducing Chore Labor on Dairy Farms* by B. R. Bookhout, Mich. Agr. Exp. Sta. Quart. Bull. *30* (1): August 1947.

A NON-TOXIC PLASTIC COATING TO IMPROVE THE KEEPING QUALITY OF CUT FOLIAGE

By C. L. HAMNER, J. B. GARTNER and F. L. O'ROURKE
SECTION OF HORTICULTURE

A PLASTIC MATERIAL, called Geon 31X, which has been recently developed by the Goodrich Chemical Company, has been tested on various cut evergreen branches, mistletoe, and Christmas trees. It has proved valuable as a means of preserving the natural attractive appearance of the plant materials for a considerable time when applied as a spray coat on their surfaces.

Cut plant materials are used extensively for decorative purposes. Evergreens, ferns, and deciduous foliage are used by florists in making wreaths and floral displays, and holly, mistletoe, and evergreen trees are used during the Christmas holiday season.

One great difficulty in handling cut plant material is its rapid wilting and drying out. Coincident with water loss is the shrivelling of tissues, loss of attractive appearance and, in many cases, loss of leaves or needles very readily after being cut.

Many attempts have been made to improve the appearance and keeping quality of cut plant material. Various degrees of success have been obtained by placing the cut stems under water, by waxing the foliage to reduce transpiration, by increasing the moisture of the surrounding air, and by refrigeration of the plant material.

It is believed by the authors that a material has now been found that will greatly improve the keeping quality of certain kinds of cut foliage. The material is a non-toxic, moisture-proof, plastic material called Geon 31X. It is a water-dispersable poly-venyl resin which upon drying leaves a transparent film with a low-vapor-moisture transmission, which will stretch considerably before it tears. Further, the material will not burn nor support combustion and, when subjected to a flame, it only chars; hence, plant material sprayed with Geon 31X tends to become somewhat fire resistant.

ARTICLE 30-38

EXPERIMENTAL

The experiments described were carried out at the College, during the period October 29-December 31, 1947.

Preliminary trials indicated that for Norway spruce *(Picea excelsa)* a spray containing Geon 31X at a concentration of 10 percent of solid material was most desirable. As a result of these preliminary findings, most of the subsequent tests were conducted with a 10-percent solution of Geon. Following advice of the Goodrich Company, a wetting agent was added to the Geon to insure better coverage on plant material.

An experiment was carried out with cut branches of Norway spruce *(Picea excelsa)*, Chinese arborvitae *(Thuja orientalis)*, American arborvitae *(Thuja occidentalis)*, and White pine *(Pinus strobus)*. Twenty uniform bundles of branches from each group were selected and weighed. Ten bundles from each group were treated with a 10-percent solution of Geon by spraying the solution onto the foliage until complete saturation was obtained. Ten bundles from each group were left untreated as checks. The treated bundles, together with those untreated, were then hung in a room in which the temperature was maintained at 85° F. with a humidity of 20 percent. The branches were then weighed at intervals to determine the amount of water lost from each group. The results are tabulated in Table 1. Untreated plants in most cases lost considerably more water than did treated

TABLE 1—The effect of Geon 31X treatment on water loss of cut branches of Norway spruce *(Picea excelsa)*, Chinese arborvitae *(Thuja orientalis)*, and White pine *(Pinus strobus)*

Material	Treatment	Water loss (percent of total weight)		
		Nov. 10	Nov. 13	Nov. 18
Norway spruce	Geon, 10 percent	0	23	48
	Untreated	0	36	61
Chinese arborvitae	Geon, 10 percent	0	20	42
	Untreated	0	31	51
Chinese arborvitae	Geon, 10 percent	0	29	51
	Untreated	0	42	55
White pine	Geon, 10 percent	0	16	36
	Untreated	0	30	51

TABLE 2—Effect of Geon treatment on water loss of cut branches of Norway spruce *(Picea excelsa)* and American arborvitae *(Thuja occidentalis)*

Material	Treatment	Water loss (percent of total weight)		
		Nov. 22	Nov. 23	Dec. 1
Norway spruce	Geon, 10 percent	0	10	49
	Untreated	0	21	67
American arborvitae	Geon 31X, 10 percent	0	17	53
	Untreated	0	18	55

plants. Untreated Norway spruce, for example, lost 61 percent of its weight, whereas the treated plants lost only 48 percent of their weight.

This experiment was repeated at a later date using only material of Norway spruce and American arborvitae, and results are recorded in Table 2.

Tests were also run with mistletoe *(Viscum album)*. Ten branches of mistletoe were sprayed with a 10-percent solution of Geon, and 10 were left untreated as checks. Weights were taken at intervals to determine water loss and are given in Table 3.

To obtain information on how this new material would work on Christmas trees, trees of Norway spruce 5-7 feet tall were cut, selected for uniformity, divided into four lots of three trees each, and treated in the following way: 1) Sprayed with a commercial wax "A"; 2) sprayed with a commercial wax "B"; 3) sprayed with a 10-percent Geon 31X solution; and 4) left untreated as checks. The trees were then placed in a room in which the temperature was maintained at 85° F. and the humidity at 20 percent. Observations were taken at daily intervals and difference between treatments noted.

Treatments with commercial waxes were not so effective in preventing needle drop and, in addition, commercial wax "A" caused

TABLE 3—Water loss on branches of mistletoe *(Viscum album)* treated with Geon 31X

Material	Treatment	Water loss (percent of total weight)		
		Nov. 19	Nov. 20	Nov. 22
Mistletoe	Geon, 10 percent	0	20	41
	Untreated	0	10	22

Fig. 1 (left). Cut Norway spruce tree 10 days after spraying with a protective coating of 10-percent Geon (Compare with Fig. 2)

Fig. 2 (right). Cut Norway spruce tree not sprayed with a protective coating (check) (Compare with Fig. 1)

marked browning of the needles after 5 days. The untreated trees, as well as those treated with the commercial waxes, started to drop their needles after 4 days and severe dropping was noted after 10 days. The trees treated with a 10-percent solution of Geon 31X maintained a fresh appearance throughout the 10-day trial and dropped only a very few needles.

Subsequent tests using smaller trees of Norway spruce completely confirmed the results that were obtained with the Geon material.

LENGTHENING THE LIFE OF CUT FLOWERS AND FLORAL GREENS BY THE USE OF PLASTIC COATINGS

By C. H. SHERWOOD and C. L. HAMNER
SECTION OF HORTICULTURE

THE LIFE of Christmas trees and cut branches of conifers used for decorative purposes has been lengthened by coating with a spray of a plastic material (Geon 31X). This material has proved useful in lengthening the life of certain flowers and floral greens as reported in the following paragraphs.

RESULTS WITH GARDENIAS

Striking results have been obtained with gardenias. In the initial experiment 12 gardenias were used; 4 were dipped in a 10-percent solution of Geon, 4 were dipped in a 20-percent solution, and 4 were left untreated. The flowers were then left out of water at room temperature (70° to 80° F.) and observed at intervals.

After 4 hours, untreated gardenia flowers began to wilt; and after 12 hours, in addition to being badly wilted, they had developed an objectionable yellowish brown color. Flowers treated with a 20-percent solution of Geon remained turgid and in excellent condition for about 36 hours, after which deterioration was quite rapid (Fig. 1). Flowers treated with a 10-percent solution remained fresh and attractive for 20 to 36 hours longer than untreated flowers. It appears from this test that the 20-percent concentration of Geon is best for gardenias.

The treatment with Geon in no way detracted from the natural beauty and appearance of the flowers. It was felt by many observers that the appearance of the flowers was improved by the treatment. Some loss in fragrance occurred from the treatment, but this loss was not great and was not undesirable.

ARTICLE 30-39

Fig. 1. Gardenia flowers showing effect of treatment with Geon 31X. Upper flower treated by being dipped into 20-percent Geon 31X solution. Lower flower untreated. (Photographed 24 hours after treatment.)

TABLE 1—*Water loss from gardenia flowers following treatment with Geon 31X*

Material	Treatment	Weight loss in percent 4 hours after treatment
Gardenia	Geon 31X, 10 percent	6.2
	Geon 31X, 20 percent	4.5
	Untreated	13.0

Water loss was reduced by the treatment, and this probably partially accounts for the fresh appearance of the flowers. Table 1 shows water loss at the end of 4 hours. At this time the control flowers were beginning to wilt.

RESULTS WITH FERN ASPARAGUS

Fern asparagus *(Plumosus asparagus)* is extensively used as a decorative green. It has one drawback, however, and that is a tendency to lose leaflets shortly after being cut. Branches from the fern asparagus were selected, divided into 30 bundles, and treated by dipping in water solutions of Geon 31X at various concentrations. Ten bunches were treated with 5-percent Geon, 10 bunches with 10-percent Geon, and 10 left untreated. The ferns were then placed in a warm room (85° F.) and the loss of weight was recorded at intervals. After 2 or 3 days, 20 to 30 percent of the leaflets from untreated plants had dropped, while on plants treated with 10-percent Geon the dropping was almost negligible over a 10-day period. Water loss was also reduced as a result of treatment as is shown in Table 2.

RESULTS WITH OREGON FERN

Oregon fern *(Polystichum acrostichoides)* is a decorative plant material, that, undoubtedly, would have more extensive use if it would last longer. Fronds from Oregon ferns were divided into 30 bundles. Ten

TABLE 2—*Water loss from fern asparagus following treatment with Geon 31X*

Material	Treatment	Weight loss in percent		
		Nov. 18	Nov. 19	Nov. 20
Plumosus asparagus	Geon 31X, 5 percent	0	18	43
	Geon 31X, 10 percent	0	5	23
	Untreated	0	35	66

Fig. 2. Oregon fern showing effect of Geon treatment. Frond on the left treated with a 20-percent solution of Geon 31X. Frond on the right left untreated. (Photographed 24 hours after treatment.)

bundles were dipped in a 5-percent Geon solution, 10 bundles were dipped in a 10-percent Geon solution, and 10 were left untreated. The bundles were then taken into a warm room at 85° F. and records taken at intervals. After about 12 hours, untreated fronds (Fig. 2) began to wilt and shrivel, and by 24 hours were badly wilted. Fronds treated with 10-percent Geon remained turgid from 24 to 36 hours longer than did untreated fronds. Water loss was much greater in untreated fronds and probably accounted for the differences in wilting (Table 3).

TABLE 3—*Water loss from Oregon fern following treatment with Geon 31X*

Material	Treatment	Weight loss in percent	
		Nov. 20	Nov. 22
Oregon fern	Geon 31X, 5 percent	0	46
	Geon 31X, 10 percent	0	42
	Untreated	0	60

Another experiment on Oregon fern showed quite clearly that a 20-percent dip with Geon 31X would be much more effective than a 10-percent dip. Although records on water loss are not available for the 20-percent dip, the loss of water was undoubtedly far less than for the other treatments. The 20-percent dip made a somewhat heavy coating but this was not objectionable on the fern.

SOME STUDIES ON TEMPERATURE ADAPTATION IN THE BABY PIG

By D. P. WALLACH, H. W. NEWLAND and W. N. McMILLEN[1]
SECTION OF ANIMAL HUSBANDRY

REPORTS FROM the Midwestern states in the spring of 1947 indicated tremendous losses of baby pigs. Smith (1937) states that chilling accounts for 3 percent of the baby pig losses, which in terms of the estimated 1948 spring pig crop means that 2,000,000 baby pigs will die from chilling. The inability of young pigs to adjust themselves to low environmental temperatures will be a contributing factor in the death of pigs which are born weak, overlaid by the sow or die from other causes.

Experienced swine producers are familiar with the erect hair, shivering and huddling of cold young pigs. Observant caretakers also know that the lighter pigs at birth suffer more in cold weather than heavier pigs, often becoming cold to the touch and dying within the first day or two after birth.

In spite of the heavy losses from chilling and the importance of an understanding of the heat control mechanism in the baby pig, very little work has been done on this subject. The purpose of this paper is to present preliminary data collected in the spring and fall of 1947 covering: 1) the temperature responses of baby pigs under barn conditions, 2) the relation of birth weight to body temperature, and 3) the temperature responses of young pigs to low and high environmental temperatures.

EXPERIMENTAL PROCEDURE

Litters of Yorkshire, Duroc Jersey, Chester White and Yorkshire X Duroc Jersey crossbred pigs were used. The pigs were farrowed in 8- by 8-foot concrete pens that were bedded lightly with shavings, and equipped with a 200-watt bulb in an open brooder. In severe

[1]The authors acknowledge the suggestions of Dr. E. P. Reineke, Department of Physiology and Pharmacology, and Prof. G. A. Brown and Dr. R. H. Nelson, Department of Animal Husbandry.

ARTICLE 30-40

weather an electric heater was used to keep the temperature above 50° F.

The first four pigs born in each litter were used. Upon birth the temperature of each pig was taken rectally with a clinical thermometer, inserted to a depth of 1.5 inches, and kept there for at least 60 seconds. After this initial temperature was taken, the pig was placed in a canvas sling with four suitably spaced holes for the feet. A piece of gauze bandage was then tied over the shoulders which held the pig in place. In most cases the pigs rested in these slings with a minimum of movement. The pig was then marked and further temperatures were taken at 10-minute intervals up to one hour. The pig was then removed from the sling and put back to nurse. Thereafter, when it was necessary to take temperatures, the pigs were held by the hind legs.

In studying the temperature responses of young pigs exposed to cold, a meat chilling room was used in which the temperatures ranged from 36° to 38° F. Pigs from two litters, 18 and 50 hours old, respectively, were allowed to run freely on the floor of the cooler, and temperatures were taken at half-hour intervals up to 3 hours.

For the heat response studies, a standard chick brooder was used in which the temperatures ranged from 118° to 120° F. The pigs remained in the brooder for 30 minutes.

DISCUSSION

The average temperature responses of 25 pigs under barn conditions show that the temperature of a new-born pig drops from 3° to 9° F. during the first hour after birth, with the average being about 4° F., as seen in Fig. 1. The sharpest drop occurs during the first 20 minutes of life, and by the time the pig is an hour old, there is a gradual increase toward normal. The average temperature of 25 pigs observed was 98° F. at 20 minutes, 100.5° at 10 hours, 101.5° at 24 hours, and 102.3° at 48 hours. At 2 days of age, the pigs had practically reached the temperature of their mothers, or 102.5° which is reported by Dukes (1943) as the normal body temperature for swine.

It may be seen from Fig. 2 that the temperature of the lighter pigs dropped faster than that of the heavier pigs. In the litters used, there was a positive intra-litter correlation of 0.71 between the birth weights of pigs and the drop in body temperature after birth. Although the data are limited, similar slopes of the regression lines of these

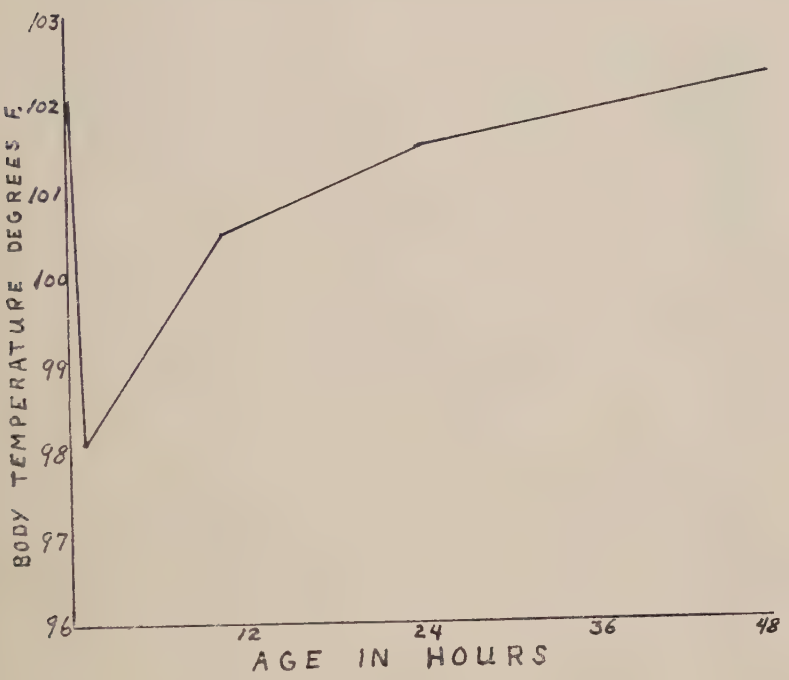

Fig. 1. Relation of age to body temperature in pigs up to two days old (average of 25 pigs).

litters and the high correlation coefficient give the data significance. These results would be expected from the work of Brody *et al.* (1945). He states that "The basal heat production per unit of body weight in homeotherms decreases rapidly with increasing weight." Also from the laws of Newton is derived the fact that the heat loss from a body is proportional to its surface area. These two statements translated into terms of this experiment seem to explain the greater temperature drop in the light pigs. This would be expected, as the lighter pig must produce more heat per unit of body weight to maintain normal temperature. The lighter pig also has proportionately more surface area from which to radiate heat than a larger pig.

These same general results were also observed in the chilling experiments in that the temperatures of the lighter pigs always dropped more than those of the heavier pigs. Four pigs from one litter 18 hours of age exposed to 34° to 36° F. for 3 hours showed a temperature drop of 2° to 4° F. depending upon the weight of the pig. Pigs of comparable weight 50 hours old were able to maintain a more nearly

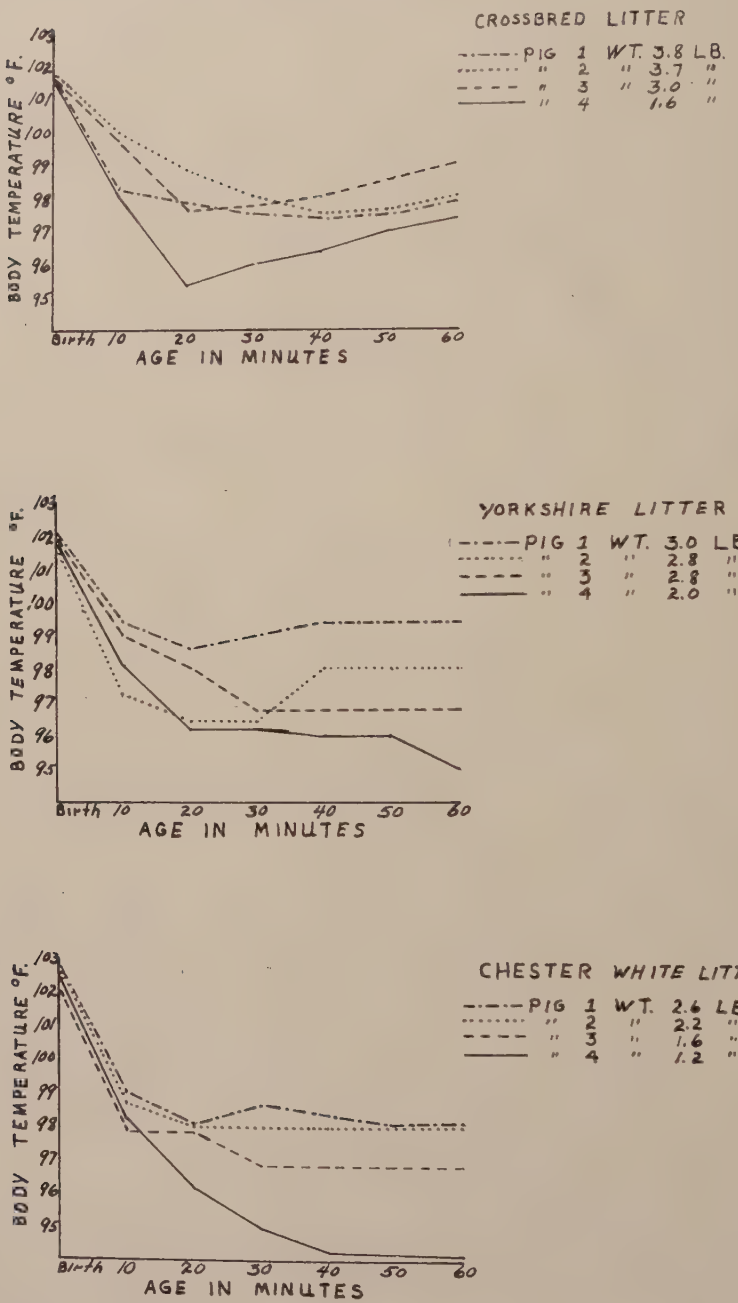

Fig. 2. Relation of body weight to temperature drop in baby pigs.

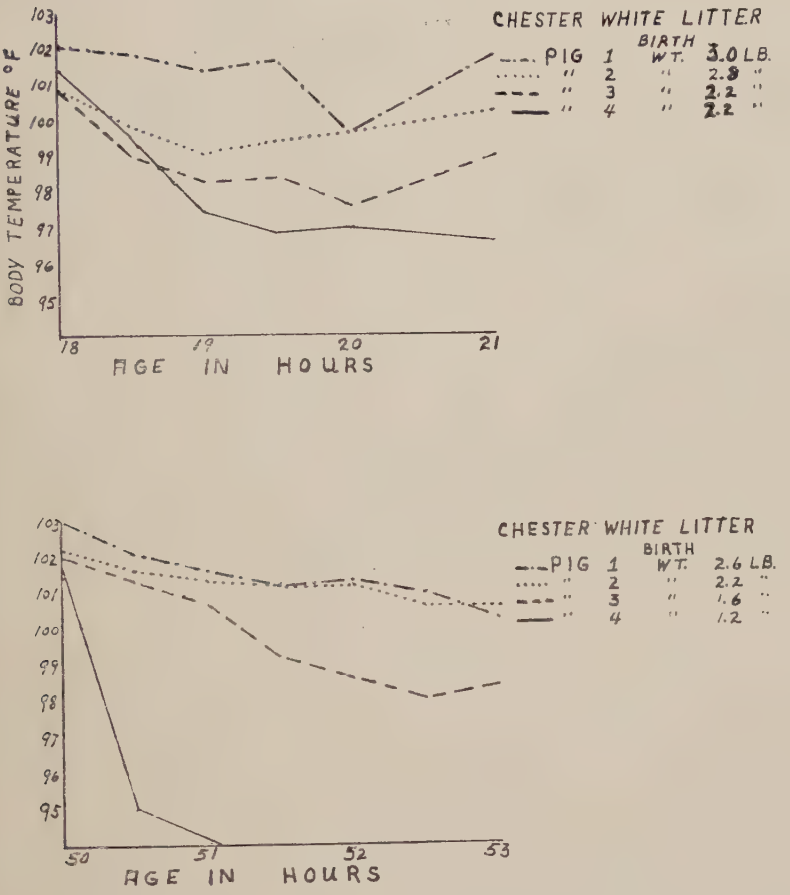

Fig. 3. Effect of chilling on body temperature in baby pigs (environmental temperature 36-38° F.).

normal temperature in the same environment (Fig. 3). This seems to indicate a more highly developed homeothermic mechanism in pigs 2 days old.

That baby pigs have no cooling mechanism capable of protecting them from excessive heat was shown when several baby pigs were placed in a chick brooder at 118° F. for a half-hour at 10 hours of age. Their body temperature rose 6° to 8° F., and the same result was observed on these pigs at 48 hours of age.

SUMMARY

1. There was a sharp drop of 3° to 9° F. in the body temperature of baby pigs immediately after birth.

2. This drop was followed by a gradual rise toward normal, which was completed at about 2 days of age.

3. At 2 days of age the heavier pigs withstood temperatures of 34° to 36° F. with less drop in body temperature than pigs of a younger age.

4. There was a significant correlation between the weight of a pig and its ability to adapt itself to its environment. Light pigs (under 2 pounds), because of greater surface area in proportion to body weight, must produce more heat per unit of body weight than heavier pigs and are unable to do this under severe conditions. They thus show a sharper drop in body temperature after birth, a slower recovery of normal temperature, and suffer first from chilling.

LITERATURE CITED

Brody, S. 1945. *Bioenergetics and Growth.* Reinhold Publishing Corporation. New York, p. 354

Dukes, H. H. 1943. *The Physiology of Domestic Animals.* Comstock Publishing Co., Inc., Ithaca, N. Y., p. 474

Smith, W. W. 1937. *Pork Production.* The MacMillan Co., New York, p. 67

RED CEDAR-APPLE AND HAWTHORN RUST DISEASE CONTROL BY SPRAYING RED CEDARS IN THE SPRING

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THE RED CEDAR rust diseases are caused by fungi *Gymnosporangium juniperi-virginianae* and *G. globosum* which have rather complicated life histories. These parasitic fungi require alternately two host groups to complete their life cycles. On rust galls on red cedars (Fig. 1, middle left) are produced spores which bring about the infection of apple and hawthorn leaves. In lesions on the apple and hawthorn leaves (Fig. 1, lower right and left) are produced spores which, in turn, reinfect the red cedars.

The planting of susceptible red cedars and flowering apples and hawthorns in close proximity to each other in ornamental plantings in parks, cemeteries, nurseries and on private properties permits the rust diseases to increase in intensity until all of these species and varieties of trees may be killed. Usually there is so much injury to the foliage that the ornamental value of the trees is seriously affected. This is especially true of flowering apples and hawthorns.

Apple and hawthorn trees can be protected from the injurious effects of these rust diseases by the judicious use of suitable fungicides such as Fermate,[1] fixed coppers, or wettable sulfurs. Such protection is afforded orchard apples by the application of one of these fungicidal compounds in sprays or dusts in the regular program to prevent the development of the highly injurious apple scab disease of leaves and fruit. However, such spray applications are often impracticable or impossible in the case of ornamental plantings, and then it becomes necessary to spray the red cedars.

With this in mind, tests were conducted to determine whether a fungicide could be safely applied to red cedar trees in the spring to

[1]Fermate, a proprietary name for ferric dimethyldithiocarbamate.

ARTICLE 30-41

prevent the production of spores on rust galls, thus protecting nearby apple and hawthorn leaves from infection.

Of the eradicative type of fungicides, Elgetol[2] was selected (1) because it had been reported to have considerable penetrating action. Elgetol was tested at the rate of ½-, 1-, and 2-percent concentrations in water. In preliminary experiments the 1-percent concentration was found best. A laboratory examination of sprayed galls showed that the lower concentration killed spores already formed but did not prevent further extension of the spore horn and later formation of more spores. The 2-percent concentration killed all spores formed and prevented further spore development but caused very severe injury to the foliage.

Using a 1-percent concentration of Elgetol, the author tested a single application on two red cedar plantings, and two applications a season on one red cedar planting. The two applications resulted in severe foliage injury which the trees outgrew later in the season.

Sites used for these spray trials were selected in ornamental plantings (Fig. 1, middle right) containing *Juniperus virginiana* and varieties *ganaertii* and *glauca*, usually two to six trees in a group, with two or more susceptible hawthorns or flowering apples within a radius of 25 to 100 feet. The sites selected were located so that there were no other red cedar trees within one-half mile. The locations designated as Mary Mayo Hall and Glenmore each had Bechtel's crab trees nearby. In the case of the northeast campus location, one *Crataegus pinnatifida*, a very susceptible Chinese variety was located about 25 feet from the cedar group. At the Ionia Memorial (Fig. 1, middle right)

[2]Elgetol, a proprietary name for a 34-percent concentration of sodium dinitrocresylate.

Fig. 1.

Upper left—Telial horns extended about ⅛ inch. Not as yet gelatinized. Trees should be sprayed when the horns are in this condition.

Upper right—Telial horns gelatinized and shedding spores after being wetted by rain. It is too late to spray now, since heavy spore dispersal has already taken place.

Middle left—Red cedar with many large galls of the cedar-apple rust.

Middle right—Typical example of red cedars planted in a memorial site, with native hawthorns in the nearby background.

Bottom left—Cedar-hawthorn rust lesions on hawthorn leaves.

Bottom right—Cedar-apple rust lesions on Bechtel's crab apple leaves and fruit.

and Evergreen Cemetery locations, the alternate host was represented by six native hawthorn trees including both the rough-leaved (very susceptible) and smooth-leaved (moderately susceptible) varieties. Of necessity, the sprayed trees were not adjacent to the untreated control plots but were within 3 miles except in the case of the Ionia location.

The sprays were applied to the cedar trees at the time when spore horns on the galls were about ⅛ to ¼ inch long. Later in the summer leaf counts were made on the pomaceous host to estimate the percentage of infection occurring. The results are recorded in Table 1.

Observations of spray treatments over a period of 5 years with a single application each season of a 1-percent Elgetol solution indicate that considerable temporary injury often occurs to branch terminal foliage of the open needle varieties of red cedar while little or no injury occurs on appressed needle varieties such as *J. virginiana* var. *canaertii* or *J. virginiana* var. *glauca*. Such injury as did occur was always outgrown in 2 or 3 months.

Bordeaux 180 (2), a regular bordeaux mixture to which has been added mono-calcium arsenite and zinc arsenite, was first tested in

TABLE 1—*Reduction of rust incidence on hawthorn and Flowering apple as a result of spraying adjacent Red cedars*

Year	Treatment	Location	Leaves counted	Leaves rusted	Percentage infection
1941	Elgetol 1 percent	Ionia Memorial	741	115	15.5%
	Elgetol 1 percent	Evergreen Cemetery	310	72	23.2
	Untreated	Field 19	396	384	96.9
1942	Elgetol 1 percent	Ionia Memorial	310	51	16.4
	Elgetol 1 percent	Evergreen Cemetery	402	31	7.7
	Untreated	Field 19	450	427	94.8
1943	Elgetol 1 percent	Ionia Memorial	894	155	17.3
	Elgetol 1 percent	Evergreen Cemetery	846	119	14.0
	Untreated	Field 19	621	593	95.4
1944	Elgetol 1 percent	Ionia Memorial	3300	296	8.9
	Elgetol 1 percent	Evergreen Cemetery	960	81	8.4
	Bordeaux 180	N. E. Campus	192	12	6.2
	Bordeaux 180	Mary Mayo Hall	311	11	3.5
	Untreated	Field 19	671	617	92.0
1945	Elgetol 1 percent	Ionia Memorial	829	102	12.3
	Elgetol 1 percent	Evergreen Cemetery	1846	54	2.9
	Bordeaux 180	N. E. Campus	776	21	2.7
	Bordeaux 180	Mary Mayo Hall	649	13	2.0
	Untreated	Field 19	925	919	99.3
1946	Bordeaux 180	Ionia Memorial	884	115	13.0
	Bordeaux 180	Evergreen Cemetery	4256	145	3.4
	Bordeaux 180	Glenmore	216	4	1.8
	Untreated	Field 19	721	692	96.0
1947	Bordeaux 180	Evergreen Cemetery	7403	128	1.7
	Bordeaux 180	Glenmore	1090	0	0
	Untreated	Field 19	500	482	96.4

Connecticut (3) for the control of cedar-apple rust and was found to be effective. This spray has been included in Michigan tests on red cedar galls in the spring. Over a period of 5 years, this treatment has reduced the incidence of rust infection on nearby hawthorn and apple foliage to a remarkable extent, and to date has produced no injury on red cedar foliage.

Some modification has been made in the original formula. Soybean flour has been used to replace fish oil as a sticker since the latter is sometimes difficult to secure and because the fishy odor is considered objectionable. Results of these tests are summarized in Table 1.

SUMMARY OF RESULTS

Applications of 1-percent Elgetol sprays on rusted red cedars resulted in reductions in the amount of infection on adjacent hawthorn leaves ranging from 93 to 73 percent less than that developing on hawthorns near unsprayed cedars. This is considered to be very good control of these rust diseases. However, considerable browning of foliage on branch tips is common and results in an unsightly appearance of sprayed trees. Such trees soon produce new leaves and by midsummer usually recover their normal appearance. Because of this injury, the use of Elgetol as a control fungicide is not recommended.

Applications of bordeaux 180 on rusted red cedars resulted in reductions in the incidence of infection on adjacent hawthorn leaves, ranging from 94 to 83 percent less than that developing on hawthorns near unsprayed cedars. No foliage injury has been observed on any red cedar tree sprayed with this fungicidal mixture throughout the five seasons in which it has been used, and therefore its recommendation is considered safe.

RECOMMENDATIONS

A single application of bordeaux 180 to red cedar trees in the spring when the horns (telia) on the galls are about ⅛ to ¼ inch extended is recommended (Fig. 1, upper left). The spray should be applied if possible just before rains cause the gelatinization and expansion of the horns. Proper timing of the spray applications is important if best results are to be obtained (Fig. 1, upper right). Thorough coverage should be made, using a finely divided spray. Pump

pressures from 150 to 450 pounds have given good results in the experimental tests.

Bordeaux 180 formula:

Copper sulfate	12 pounds
Lime (fresh hydrated)	12 pounds
Mono-calcium arsenite	2 pounds
Zinc arsenite	8 pounds
Soybean flour (sticker)	1 pound
Water	100 gallons

Fractional amounts of this formula may be prepared using the same proportional amounts of the materials. The hydrated lime and the copper sulfate are mixed first according to the regular methods for making bordeaux mixture. Then the arsenites and the soybean flour are added.

It is advisable to contact your spray material supply dealer as early as possible in order to obtain these arsenite compounds which are not regularly sold.

LITERATURE CITED

(1) Forrest C. Strong and Donald Cation 1940
Control of Cedar Rust with Sodium Dinitrocresylate
Phyto Path. *30*, No. 11, p. 983

(2) G. W. Keitt and D. H. Palmiter 1937
Potentialities of Eradicant Fungicides for Combating Apple Scab and Some Other Plant Diseases
J.A.R. 55: 397-438

(3) Rush P. Marshall 1941
Control of Cedar-Apple Rust on Red Cedar
Trans. of the Conn. Acad. of Arts and Sci. 34: 85-118

THE EFFECT OF BUFFERS ON THE GROWTH-INHIBITING PROPERTIES OF SODIUM 2,4-DICHLOROPHENOXYACETATE

By E. H. LUCAS, IRMA M. FELBER, C. L. HAMNER, and H. M. SELL
SECTIONS OF HORTICULTURE AND AGRICULTURAL CHEMISTRY

IN TWO earlier reports (1, 2) preliminary account was given of the increased effect of the sodium salt of 2,4-dichlorophenoxyacetic acid (abbreviated "2,4-D" in this paper) when it was applied simultaneously with onion extracts or acids. In these instances the formative effect of nonherbicidal doses and the herbicidal action of higher concentrations or of larger quantities applied were comparable to those of the water-insoluble acid and esters. The advantages of such stimulation are obvious since both acid and esters are more expensive than the salt, inconvenient in handling because of their insolubility in water, and dangerous to plant life because of their volatility.

The role of the enhancing effect of onion extracts was further investigated, but has so far not given any conclusive results. In the course of this study the buffering properties of onion and other plant extracts were considered among possible reasons for their specific performance. This led to an examination of the influence of buffer solutions prepared for various pH levels. The results of this examination are presented in the present publication.

EXPERIMENTAL

As in earlier experiments, certified seed of the Red Kidney bean was used for the production of test plants. The experimental procedure was somewhat altered since it was desired to eliminate certain variations observed in the results of earlier experiments. The seed was weighed or screened to insure uniformity; only medium-sized beans of 0.5-0.6 g. weight were planted. One seed was planted per 4-inch pot. The plants were treated in the general manner described in earlier papers (1, 2); however, since the dropper bulb micro pipettes previously used did not deliver drops of sufficient uniformity, 1 drop

ARTICLE 30-42

(approximately 57 mgm.) was applied to each plant by means of specially selected 1.5 ml. pipettes. A new procedure, proposed in a recent publication (3), was used for the evaluation of the results obtained. Terminal growth, lateral growth, and proliferating tissue were weighed separately and plotted graphically.

On account of higher temperatures, the beans grew more rapidly in the tests described than in earlier experiments. Plants treated at the same stage of development as in experiments previously reported were 6-8 days old as compared with an age of about 10 days, the average in earlier experiments.

The test materials were solutions of the sodium salt of 2,4-dichlorophenoxyacetic acid (obtained as C.P., but recrystallized until constant melting point was attained) at pH 2, pH 3, pH 4, pH 5, pH 6, and pH 7. Each solution was used unbuffered and buffered. The following buffers were prepared: for pH 2, 0.2 N hydrochloric acid and 0.2 N potassium chloride; for pH 3, 0.1 M potassium acid phthalate and 0.1 N hydrochloric acid; for pH 4, pH 5, and pH 6, 0.1 M potassium acid phthalate and 0.1 N sodium hydroxide; for pH 7, 0.1 M monopotassium phosphate and 0.1 N sodium hydroxide. For the adjustment of the unbuffered solutions orthophosphoric acid and sodium hydroxide respectively were used.

DISCUSSION OF RESULTS

It was found that 2,4-D when applied in buffered solutions exerted a far superior inhibiting effect than when dissolved in unbuffered liquids at pH 4, pH 5, pH 6, and pH 7. At pH 2 and pH 3, the acidity of the solution sufficed to increase the growth-inhibiting effect to maximum efficiency (2); whether a solution within this range is buffered is immaterial. At higher pH levels, however, the situation

TABLE 1—*Effect of pH in unbuffered 1,000 p.p.m. solutions of sodium 2,4-dichlorophenoxyacetate upon terminal growth of bean plants*

pH	Terminal growth of 10 plants in grams
2	0.0
3	0.4
4	36.2
5	41.2
6	69.0
7	64.7

TABLE 2—*Effect of pH in buffered 1,000 p.p.m. solutions of sodium 2,4-dichlorophenoxyacetate upon terminal growth of bean plants*

pH	Terminal growth of 10 plants in grams
2	0.0
3	0.2
4	0.6
5	0.0
6	0.8
7	0.0

changes strikingly as Figs. 1-5 demonstrate. Tables 1 and 2, as well as the diagrams (Figs. 6 and 7), support the visual observations.

Tests with 2,4-D in solutions at pH 8 and above showed inconsistent relations between the effect of the buffered and the unbuffered preparations, and are therefore not considered in this report.

In Fig. 1 the growth response of bean plants is illustrated according to ascending pH levels of the applied unbuffered 2,4-D solutions. At pH 2 the injurious effect is lethal; at pH 3 terminal growth is in-

Fig. 1. The effect of pH changes in unbuffered solutions containing 1,000 p.p.m. of sodium 2,4-dichlorophenoxyacetate upon the inhibition of shoot growth of bean plants. Plants from left to right show a gradual decrease of inhibition of growth in accordance with the rising pH values of 2, 3, 4, 5, 6 and 7.

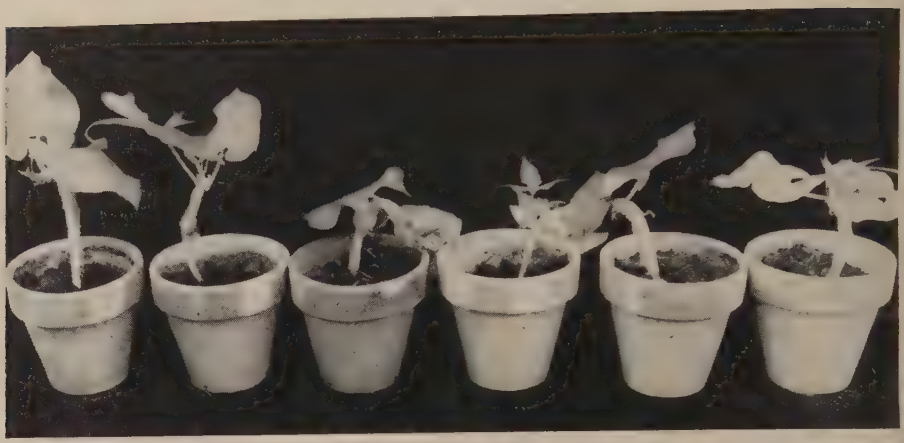


Fig. 2. The effect of pH changes in buffered solutions containing 1,000 p.p.m. of sodium 2,4-dichlorophenoxyacetate upon the inhibition of shoot growth of bean plants. At pH levels, from left to right, of 2, 3, 4, 5, 6 and 7, the treated plants show equal growth inhibitions.

hibited, but weak cotyledonary shoots and lateral shoots from the axils of the primary leaves develop; at pH 4 only one lateral shoot with defective trifoliate leaves is formed; at pH 5 abundant lateral growth is produced, but all the leaves show the characteristic mosaic-like symptoms; at pH 6 the plant looks almost normal, except for the remaining curvature of the first internode, from which adventitious roots arise; at pH 7 terminal growth proceeds, but some of the compound leaves are modified in structure.

The result of treatments with buffered 2,4-D solutions at the same pH levels, as were used in the experimental series of Fig. 1, is shown in Fig. 2. Almost complete inhibition of growth of all plants is evident, regardless of the pH of the solutions applied, ranging from pH 2 to pH 7. The first two plants at the left seem taller, because the original curvature of their first internodes has disappeared. All plants died shortly after the picture was taken.

The difference between effects of buffered and unbuffered 2,4-D solutions at pH 2 are practically none, although the lethal injuries may vary (Fig. 3). In Figs. 4 and 5, however, there are very remarkable differences in growth subsequent to treatments with buffered and unbuffered 2,4-D solutions at pH levels of 5 and 7, respectively.

An explanation for the effect of the buffer solutions cannot be offered at the present time. It is assumed that the buffering action,

rather than a specific constituent of the buffer solution, is responsible. The equally inhibiting effect of 2,4-D in the variety of buffer solutions used seems to indicate this. Although at the low pH levels, no enhancing effect of the buffer solutions was recorded, it must be noted that two different buffers were used, and that the acidity of the solutions already insured a maximum inhibiting effect.

It was considered that the enhancing effect on the action of 2,4-D exerted by onion extracts and by buffers might be possibly correlated on the basis of their buffering properties. The buffer value according to VanSlyke (4) was therefore determined for a representative onion extract and for a buffer solution of the same pH value. It was found that 0.26 ml. of 0.1 N HCl was required to shift the pH of onion extract

Fig. 3. On the left: plant treated with unbuffered 2,4-D solution at pH 2. On the right: plant treated with buffered 2,4-D solution at pH 2.

Fig. 4. On the left: plant treated with unbuffered 2,4-D solution at pH 5. On the right: plant treated with buffered 2,4-D solution at pH 5.

from pH 5.6 to pH 5.1, while 6.9 ml. was necessary to shift the pH of the buffer solution within the same range. The buffer value, or buffer index, is, according to Small (5), a direct definite measure of the buffer capacity. It is calculated as dB/dpH, where dB is the number of gram-equivalents of acid or base required per liter for the observed change of pH in one liter of buffer solution. The formula for the buffer index is therefore: $\frac{\text{conc. of acid x vol. of acid in ml.}}{1000}$, divided by the shift in pH. The buffer value for the onion extract, calculated on the basis

of this formula, was 0.0052; the buffer value for the buffer solution was 0.138. This is valid proof that there is no correlation between the buffering properties of onion extract and its stimulating effect. The pH range of onion extract (between pH 5 and pH 6) also eliminated the possibility that acidity might be the factor responsible for the stimulation obtained. It seems, therefore, that in the cases of onion extract, of acids and of buffers, three different enhancing factors are in operation. These factors may, however, act on one and the same mechanism which would then be directly responsible for the increased effect of 2,4-D.

Fig. 5. On the left: plant treated with unbuffered 2,4-D solution at pH 7. On the right: plant treated with buffered 2,4-D solution at pH 7.

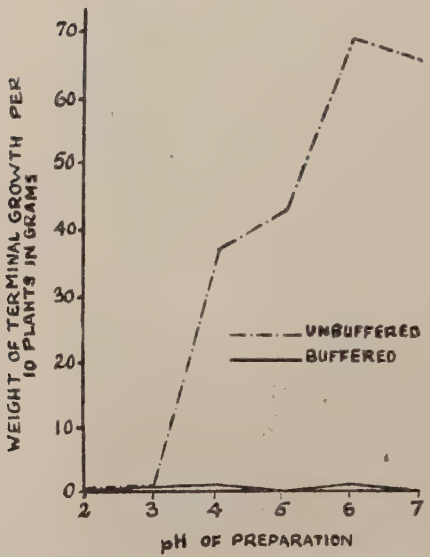


Fig. 6. Terminal growth of bean plants treated with 1,000 p.p.m. of sodium 2,4-dichlorophenoxyacetate at different pH levels.

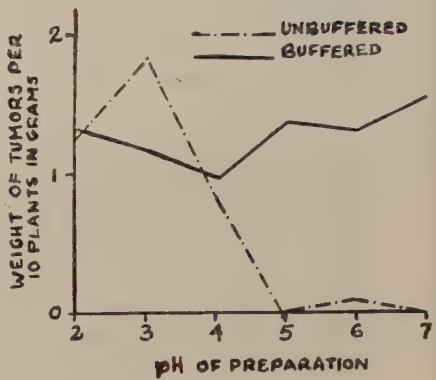


Fig. 7. Proliferation of tissue subsequent to treatment of bean plants with 1,000 p.p.m. of sodium 2,4-dichlorophenoxyacetate at different pH levels.

SUMMARY

The effect of buffers on certain growth-inhibiting properties of sodium 2,4-dichlorophenoxyacetate is reported. At pH 2 and pH 3 buffered and unbuffered solutions of 2,4-D exerted similarly strong inhibiting effects on bean plants. At pH 4, pH 5, pH 6, and pH 7, however, the inhibiting effect of 2,4-D was far greater in buffered than in unbuffered solutions. In the former it equalled the effect obtained at the low pH levels. At pH levels of 8 and above, the relationship between buffered and unbuffered solutions became erratic and requires further investigation.

Neither the buffer system nor the acidity level furnishes an explanation for the increased efficacy of 2,4-D solutions prepared with onion extract. In this case another, as yet unknown, factor must be responsible for the apparently synergistic action.

REFERENCES

1. E. H. Lucas and C. L. Hamner, 1947.
Mich. Agr. Exp. Sta. Quart. Bul., *29:* 256

2. C. L. Hamner, E. H. Lucas, and Harold M. Sell, 1947.
Mich. Agr. Exp. Sta. Quart. Bul., *29:* 337

3. Irma M. Felber and E. H. Lucas, 1947.
Mich. Agr. Exp. Sta. Quart. Bul., *30:* 170

4. D. D. VanSlyke, 1922.
Jour. Biol. Chem., *52:* 525

5. J. Small, 1946. *pH and Plants.* New York.
D. Van Nostrand Company, Inc.

INSECTICIDES INCREASE LEGUME SEED

By C. E. PEDERSON[1]
SECTION OF ENTOMOLOGY

LEGUME SEED production has fallen off steadily in Michigan for the last 15 years. During this period more and more experiment station workers, extension specialists, growers, and other interested persons have joined in a search for the factors bringing about this reduction. Considerable attention has been given to varietal differences, cultural practices, soil conditions, pollinization and seed setting, and harvesting practices. While it has long been known that many species of insects are injurious to legumes, some of these affecting seed production directly by their feeding and oviposition, no record has been made in Michigan of what effect the control of these insects will have on seed production. Rather extensive field trials were conducted during 1947 with sprays and dusts of several insecticides as a preliminary study of the problem of pest insect influence on seed production.

METHODS

Field treatments for insect control included both first- and second-stand crops. First-stand fields were treated in Antrim, Alcona and Ingham counties, and second-stand fields were used in Tuscola and Lenawee counties. An attempt was made to use test plots of approximately one acre in size. The actual plots varied from 0.7 to 1.28 acres, the size being determined by field dimensions. They were laid out as parallel strips across the length or breadth of the field. Where possible, as on larger fields, a strip near the center was reserved as an untreated check plot. The plots were generally laid out so that strips of at least an acre remained on either side which also served as check plots. Larger field plots of up to 5 acres were treated in two instances.

[1]**Acknowledgment**—Appreciation is hereby extended to members of the Department of Farm Crops, who provided general information and suggestions, and especially to Mr. Carl Hanson, Graduate Assistant, for his valuable aid in obtaining some of the seed yields and threshing of the small quadrat samples; to county agricultural agents and growers in the different counties, for their cooperation in locating suitable stands, use of fields and aid in obtaining combine yields; and to the author's colleagues in the Department of Entomology for their aid and suggestions.

ARTICLE 30-43

The dust and spray applications were applied shortly before the plants came into bloom. This is generally referred to as the prebloom or bud stage. A few treatments were applied on new growth of second-stand alfalfa and red clover.

DUST TREATMENTS

Most of the field treatments were applied as dusts. These dusts were pyrophyllite based and included the following formulations: 5-percent DDT, a combination of 2½-percent DDT with 0.25-percent gamma benzene hexachloride (BHC), a 0.36-percent gamma benzene hexachloride (or 3-percent BHC), 3-percent chlordane, and another combination of 3-percent DDT with 2-percent chlordane. The initial stockpile of dust materials supplied all the experiments. Approximately 30 pounds of the dust formulations was applied per acre. Unless noted otherwise, and excepting small errors in application, this was the dosage applied on all the test plots listed in the tables.

All the dusts were applied by an 18-nozzle Niagara field duster which was transported in a jeep-drawn, two-wheeled trailer. The nozzles were equally spaced on a 20-foot boom, with a ground clearance of approximately 16 inches. A canvas apron, which was hung along the length of the boom, covered the nozzle openings and trailed for a distance of 6 feet. This shielded the nozzle openings from air currents. A longer apron would give additional protection from dust drifting, by keeping the newly emitted dust near the ground and, at the same time, giving it a better chance to settle on the plants within the dusted strip. However, dust drift was not of any great significance in any of the trials cited in this paper.

SPRAY TREATMENTS

All the spray treatments referred to in the tables, illustrations and the general discussion were made on fields in Antrim County. They were applied by a tractor-drawn potato sprayer, equipped with a 20-foot spray boom. The 18 wide-angled nozzles were so arranged that the spray hit the plants from above and from the sides. Approximately a hundred gallons of spray was applied per acre. The materials used in spraying were all in a 50-percent wettable powder form and were added in the amounts per hundred gallons of water to give the same dosage per acre of actual insecticidal material as in the dust treatments.

Fig. 1. Bundles of alfalfa stems from untreated check and DDT-treated areas 3 weeks after spraying. While the untreated area had only a few scattered blooms, the treated area showed a profusion of blooming and, on the average, stood 4 to 6 inches taller.

A 20-acre field of very uniform stand alfalfa in Antrim County was used to test the insecticides, both as dusts and as sprays. First, a series of plots was treated with the different dusts. Then, on the other side of a 100-foot-wide median check strip, a series of plots

TABLE 1—*Seed yields on dusted and sprayed plots of first-stand alfalfa in Antrim County. Field No. 1*

Treatment	Yield in pounds per acre*			
	Dusted plots		Sprayed plots	
	From combine samples	From quadrat samples	From combine samples	From quadrat samples
Untreated checks	27	128	41	107
Benzene hexachloride	41	272	97	262
DDT with benzene hexachloride	62	194	99	248
DDT (30 lb. dust, 1½ lb. actual DDT per acre)	71	245	100	263
DDT (45 lb. dust, 2¼ lb. actual DDT per acre)	79	249	122	307
Chlordane	62	232	65	187
DDT with chlordane	67	176	74	251
Untreated checks	28	89	28	89

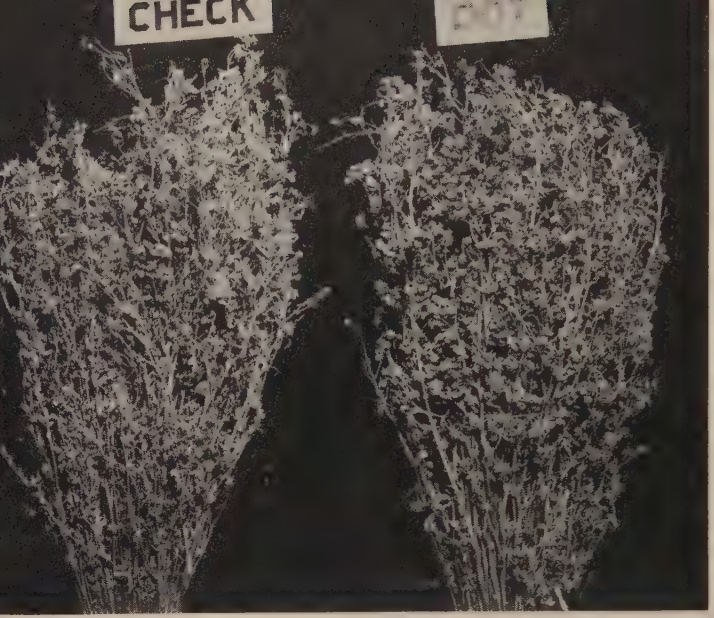
*The quadrat samples were cut 13 days prior to combining. Heavy rains fell during this period and caused a big reduction in seed yield.

was treated with sprays which duplicated the dust dosages. Results of this set of trials are given in Table 1.

Samplings of the insects present in the field plots were made by net sweepings both before and after treatments. These gave a good indication of what insects were present, their actual numbers, and also how they were affected by the insecticides. The findings of these samplings will not be discussed in this report.

YIELD SAMPLING

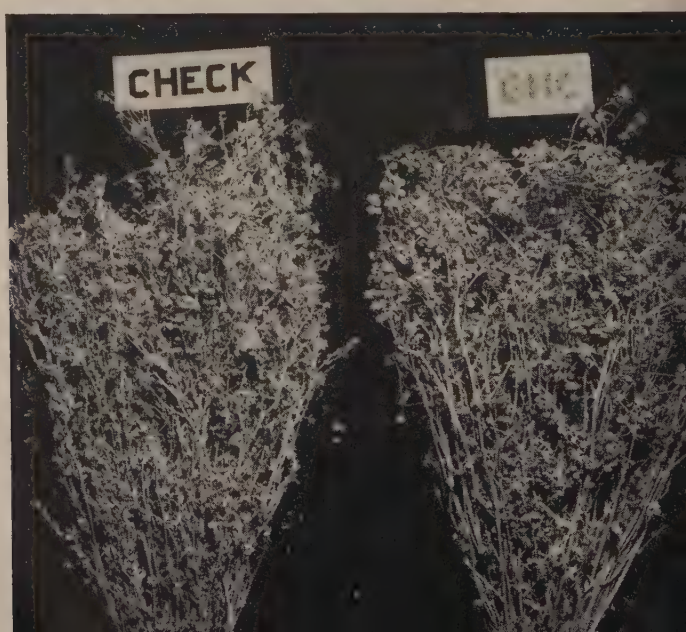
To establish the resultant yields, two methods of sampling were used on most of the trial fields. Large-scale field yields were obtained by combine samples at harvest time. The methods by which these were sampled varied. Some of the yields were obtained by combining a measured length of windrow, the width represented by the windrow also being known. In others the entire plot was combined separately with the combine cuts made in only one direction. The combine yields given in the tables are weights of clean seed per acre. A second type of yield sampling was made by cutting one square yard quadrats in five representative locations in each treated plot and each check area before the fields were harvested. These samples were placed in cloth sacks and hung up to dry. Later they were threshed and the seed cleaned and weighed. The yield per acre was computed on the basis of the weight of clean seed obtained from the 5 square yards sampled.



A. (above) Untreated check and DDT-treated bundles.

Fig. 2. Representative bundles of treated and untreated alfalfa cut when the treated plants were well matured. The untreated plants still bore considerable green foliage and only about one-fourth of their seed pods showed any degree of ripening.

B. (below) Same untreated check with bundle from plot treated with benzene hexachloride.



WEATHER INFLUENCES

In all of the counties where trials were made, with the exception of a few of the test plots in Alcona County, heavy and intermittent rains, immediately preceding and during the normal harvesting period, reduced yields considerably by causing shattering of seeds from erupting pods. These rains also caused lodging and brought on new vegetative growth which smothered the ripening seed stand before harvesting could be completed. Nearly all the quadrat samples were cut before these rains set in. Therefore, the results shown in pounds per acre for the two methods of sampling on any one plot are not necessarily comparable, except possibly for the effect of this rainy period on seed reduction. However, when one compares the effectiveness of different materials on the same series of plots, the relative yield increases or decreases should be expected to be about the same for the two methods of sampling. There is one definite exception to the foregoing statement. It should be noted that the seed pods in many of the treated plots were much advanced in ripeness as compared with those in their respective check plots. This unquestionably led to the shattering out of a greater percentage of seeds in some of the treated plots.

RESULTS AND DISCUSSION

The results of the spraying and dusting trials are given in the tables 1-5. The order in which the treatments are listed is the same as that of the plots in the field. The fields on which the first stand was left for seed produced the highest yields as well as some of the most striking yield differences. The second-stand seed crops did not produce very well. The seed set was poor-to-average, and much of it shattered out during the September rains. A third stand of heavy vegetative growth made harvesting of second-stand alfalfa very difficult.

All first-stand alfalfa treatments were made in Antrim and Alcona counties. The fields treated in Antrim County produced the greatest yield increases. On one field three treated plots produced from

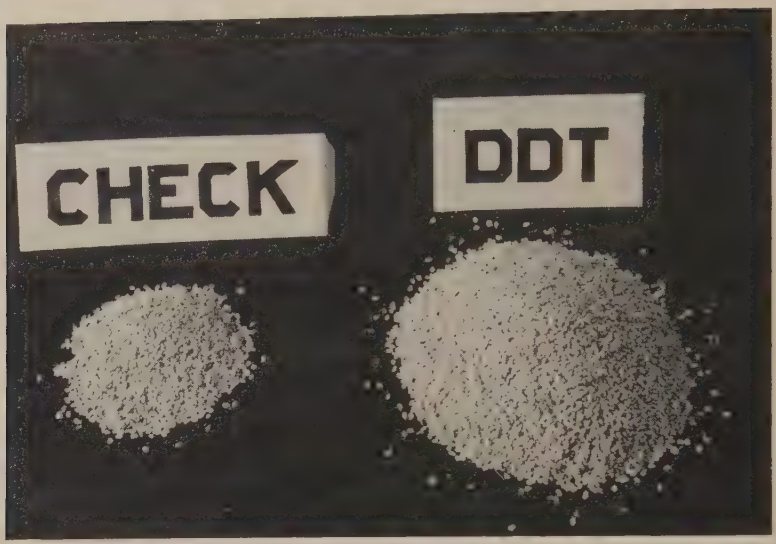


Fig. 3. The yield from 5 square yard quadrats from untreated check and DDT-dusted alfalfa.

eight to ten times as much seed per acre as the check area (see Table 2). Table 1 shows the results from another field where all the dust formulations were tested, and, in addition, these treatments were also duplicated as sprays. It will be noted that treated plots yielded from two to three times as much seed as the untreated check areas. A somewhat higher yield in the sprayed plots might lead one to conclude that spraying is more effective than dusting. However, there

TABLE 2—*Seed yields on sprayed plots of first-stand alfalfa in Antrim County. Field No. 2*

Treatment	Yield in pounds per acre	
	Combine samples*	Quadrat samples
Untreated check		29
DDT	94	242
Benzene hexachloride	203	231
DDT with benzene hexachloride (dosage—double strength)		285

*The benzene hexachloride and DDT with benzene hexachloride plots were combined as one plot. The DDT plot was combined two weeks later following intermittent rains. The grower did not consider the check area worth harvesting.

TABLE 3—*Seed yields on dusted plots of first-stand alfalfa in Alcona County*

Treatment	Yield in pounds per acre*			
	Field No. 1		Field No. 2	
	Combine samples	Quadrat samples	Combine samples	Quadrat samples
Untreated check			154	350
DDT, 30 lb. per acre	29**	320	197	533
DDT, 60 lb. per acre	107**	332		
DDT with chlordane	145	308		
Untreated check	69	189		
DDT with benzene hexachloride	130	296	169	252
Benzene hexachloride	155	319		
Untreated check			207	

*There was a two weeks interim with intermittent rains between the dates of quadrat sampling and combining. Field No. 2 laid in swaths during this period.

**Difficulties with combine adjustments and poorly dried swaths undoubtedly accounted for the discrepancy in the yields of the DDT plots in Field No. 1.

are many factors to be considered. For example, the rather dry conditions of the vegetation the morning that the dusts were applied did not promote a good sticking surface for dust particles and much of the material was lost to the ground.

The alfalfa yields in Alcona County are represented in Table 3. A third field is omitted because of rather unreliable samplings of yield. No quadrat yields were obtained. The combine yields showed from 4 to 5 bushels of clean seed per acre on all the plots, with the untreated check as good or better than the treated plots.

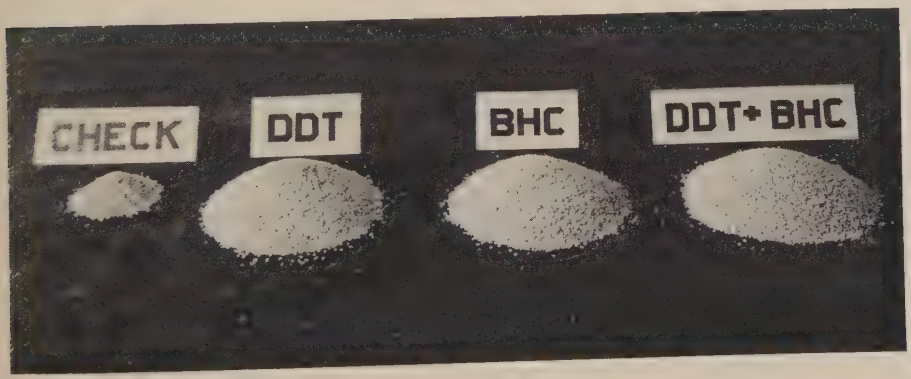


Fig. 4. The yield of alfalfa seed from 5 square yards of representative area in untreated check and plots treated with DDT, benzene hexachloride, and DDT with benzene hexachloride, respectively. (The samples are from the same field as that represented in Fig. 2.)

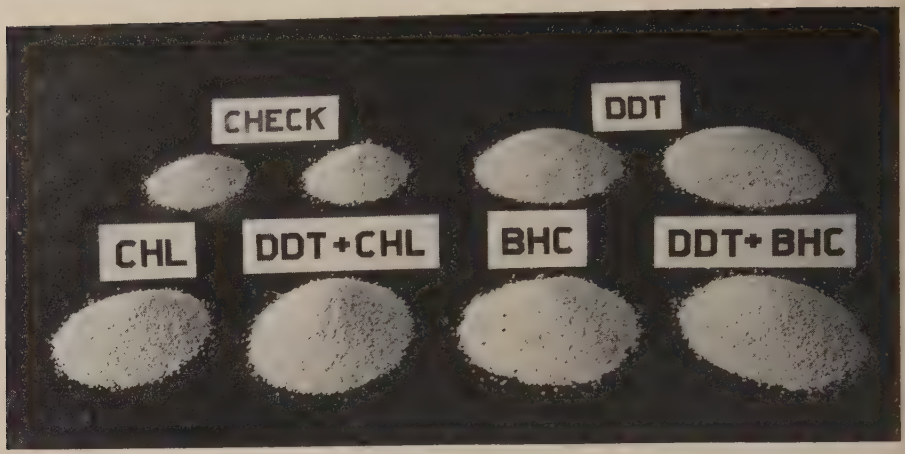


Fig. 5. The yield of alfalfa seed from 5 square yards of representative area in eight test plots. (See Table 1, sprayed plots, quadrat samples, for the calculated yield per acre of the samples shown.)

The results of dust trials on second-stand alfalfa are shown in Table 4 and part of Table 5. The first stand on these fields was cut for hay around July 1. Although both of these fields appeared fairly uniform in midseason, the yields from the untreated checks, as well as from the other plots, show that there was great variation from one side to the other. In the Lenawee field, bacterial wilt was prevalent among the plants in untreated check No. 2 and the three neighboring plots. The yield result on the plot which received two applications of DDT dust is questioned. Quadrat samples from this field are being processed at the time of writing and it is believed that these will show just as high a yield on this plot as on the neighboring plot which received the early DDT treatment.

TABLE 4—*Seed yields on dusted plots of second-stand alfalfa in Tuscola County*

Treatment	Yield in pounds per acre	
	From combine samples	From quadrat samples
Untreated check No. 1	33	36
Benzene hexachloride	47	50
Untreated check No. 2	42	63
Chlordane	57	74
DDT, 25 lb. per acre	69	124
DDT, 30 lb. per acre	73	.....
DDT with chlordane	82	145
DDT with benzene hexachloride	77	149
Untreated check No. 3	70	117

TABLE 5—*Seed yields on dusted plots of second-stands of common red clover and alfalfa in Lenawee County*

Treatment	Combine yield in pounds per acre	
	Clover	Alfalfa
Untreated check No. 1	31	49
DDT, applied immediately after first cutting was removed	46	72
DDT, two applications, one immediately after first cutting and one in prebloom stage	55	55
DDT, in prebloom stage	37	58
DDT with benzene hexachloride	36	46
Benzene hexachloride	.....	28
DDT with chlordane	.....	25
Untreated check No. 2	30	11

A mammoth clover field in Ingham County was dusted in late June. Drouth and other factors led to a relatively poor yield. Certain areas of the field were so poor that they were cut out in harvesting and, as a result, a satisfactory check was not obtained from the combine samples. However, the quadrat samples taken on this field showed the following yields per acre for the treatments indicated: 34 pounds on untreated checks, 98 pounds on DDT with chlordane, 72 pounds on DDT (50 pounds of dust per acre), 40 pounds on DDT (20 pounds of dust per acre), 55 pounds on DDT with benzene hexachloride, and 35 pounds on benzene hexachloride.

The red clover trials, listed in Table 5, indicate that the early dusting was the most effective application. This is a factor which requires further testing. It is quite likely that both first- and second-stand seed crops would benefit by an early treatment, that is, an insecticide application while the new growth is less than 6 inches in height. Stunting due to insect injuries may be greater at this stage of growth than is generally recognized.

Observations made during the course of the dusting and spraying trials indicate that the use of some of these materials also increased the hay yield. However, residues of these poisons are known to remain on the plants for a long time. Because of this residue problem, none of the materials listed in this paper can be considered safe to use on vegetation which will be fed to livestock. Therefore the use of any one of these on forage stands should be discouraged until the safety factors are determined. The same precautions should be observed when contemplating feeding of straw from treated fields or grazing animals on these fields.

SUMMARY AND CONCLUSIONS

1. Formulations of DDT, benzene hexachloride and chlordane were tested against pest insects on alfalfa and clover grown for seed. All of these, alone or in combination, promoted yield increases.

2. DDT was as good or better than the other formulations in most of the trials. It was generally applied at the rate of 1.5 pounds of actual DDT per acre, but two or three applications of larger dosages gave slightly added increases in yield.

3. Benzene hexachloride gave results which show that it was almost as effective as DDT. A combination of this material with DDT may prove very effective as a "shotgun" treatment against insects which reduce legume seed production. A pound of 12-percent gamma benzene hexachloride, or 2 pounds of 6-percent gamma BHC, per acre gave good control of certain insects that were only moderately affected by DDT.

4. Chlordane did not give as good results as the other materials, although a combination of this material with DDT showed promise.

5. The suggested time for dusting or spraying alfalfa is the prebloom, or bud, stage of development. No applications should be made while the plants are in bloom because of the toxicity of these materials to pollinating insects. There are some indications that earlier treatments may be very important. In fact, the presence of large numbers of one or more pest insects on young growth can be expected to cause some degree of injury. Eliminating these will remove one retarding factor affecting the growth of the plant.

6. Vegetative materials treated with the insecticides cited are not considered safe for use as forage. Feeding of treated hay or straw, or grazing livestock on treated fields, should be avoided. There is evidence of increases in forage yields with the use of these materials, but as long as they are not considered safe, none of these insecticides is recommended for this purpose.

THE CHEMICAL CONTROL OF GRAIN WINDBREAK ROWS IN MUCK CROPS

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THE CONTROL of interplanted windbreak rows of grain in muck crops can be effectively accomplished by spraying. This method of control eliminates an objection to a very desirable practice to minimize wind damage.

Wind damage during the early stages of growth is one of the greatest hazards in the production of onions and other row crops on muck land. It is necessary to supplement the large windbreak hedges of willow or other woody plants with rows of wheat or barley which are seeded between the rows. The erect and rapid-growing grain reduces the blowing of muck and often saves the young crop from destruction.

The chief objection to interplanting rows of grain between onions or other row crops is the difficulty and cost of removal, particularly in wet seasons. The wheel hoe has been the most common implement employed, and much hand labor is required. Because of the customary close planting of onions, power cultivating equipment has not proved very useful in cutting cut grain, particularly if excessive moisture causes a delay in operations and the grain gets too large. Owing to the removal problem, grain is usually planted at intervals of several rows, frequently one in four. Growers thus compromise between maximum wind protection and economy in grain removal.

In 1946 Dr. Robert Lucas of the William Gehring Farms, Rensselaer, Indiana, became interested in the possibilities of killing or reducing the growth of grain with a chemical spray applied under a hood to prevent spray mist from reaching the onions. His early attempts at accomplishing this end were only partially successful owing to the limitations of the hoods employed. In 1947 hoods originally designed by the senior author for experiments on the chemical

ARTICLE 30-44

cross-blocking of sugar beets proved more successful. At low pressure, i.e. 30 to 40 pounds per square inch, the spray was entirely confined within the hood as it traveled down the row of grain between the rows of onions. Although this method of killing or reducing the growth of protective grain should still be considered in the developmental stage, the hoods employed are described here for the benefit of those who may be interested in experimenting with them. They may possibly find application in other spraying problems where a herbicidal spray must be confined.

EXPERIMENTAL APPARATUS

The success of this method of eliminating windbreak rows of grain depends largely upon the design of the hoods or shields which confine the spray. Their design must permit them to follow the irregular contours which might occur in the soil and allow sufficient space for the pressure of the spray to expand itself. Each hood had three sections which were hinged together by small bolts (Fig. 2). The leading end of the hood was enclosed by a canvas skirt which allowed the

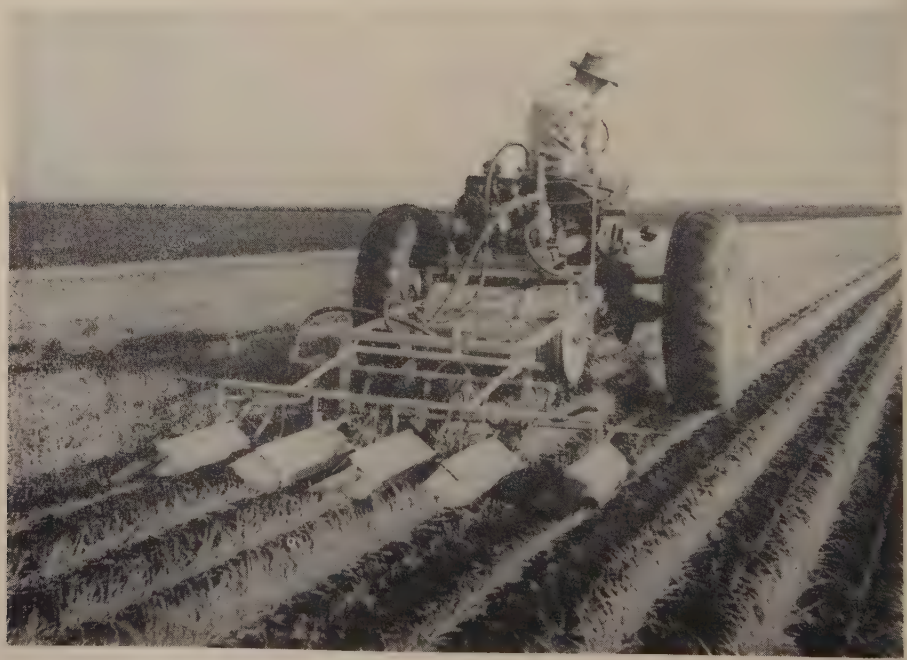

Fig. 1. Unit used in 1947 applying contact spray to rows of grain between rows of onions.

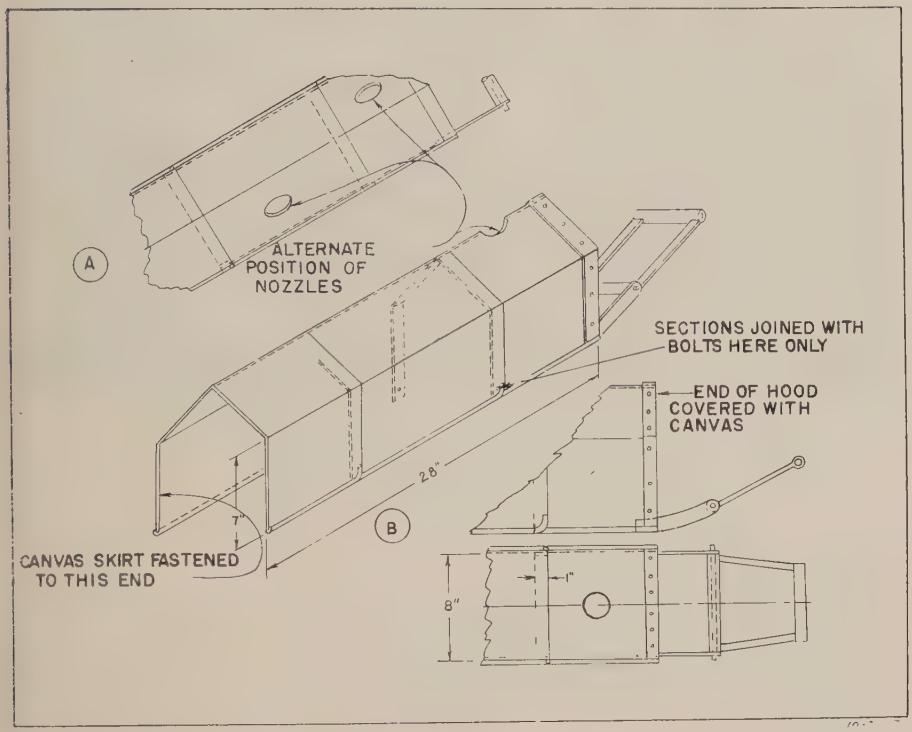

Fig. 2. A detail drawing of the hoods used in the tests. Top view (A) shows an alternate nozzle arrangement.

grain to be sprayed under the hood in an erect position. A canvas skirt was also attached to the trailing end of the hood.

A single bar attached to a rigid frame behind the tractor trailed the hoods over rows of grain (Fig. 1). The controls for the spray and for raising the hoods were readily accessible from the tractor seat. A hinged mounting on the tractor drawbar carried the front of the apparatus while the rear was transported on a single caster wheel. This experimental model used an engine-driven rotary (empellor) pump.

RELATION BETWEEN SPRAY NOZZLES AND RATE OF TRAVEL

One nozzle under each hood will apply suitable quantities of liquid when the grain growth is not profuse (B Fig. 2). Limited tests proved

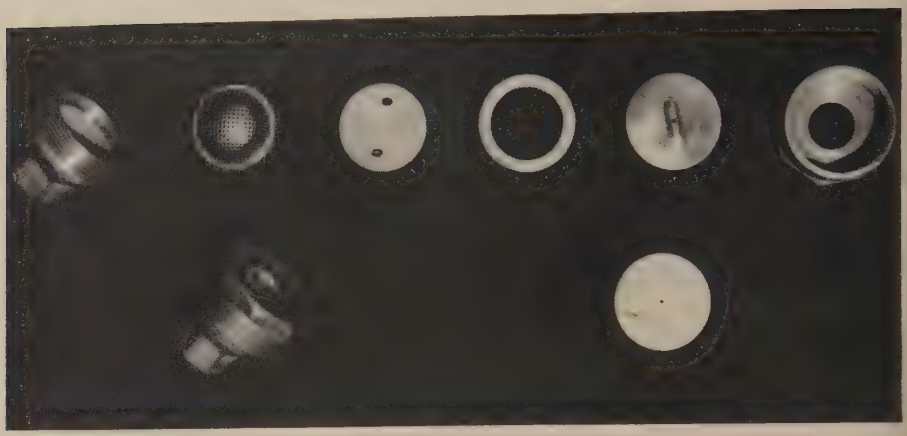

Fig. 3. Integral parts of the spray nozzle used showing assembled nozzle and the alternate cone-spray disk.

that for tall or dense growth the performance was greatly improved when two nozzles were placed at right angles (A Fig. 2). A more uniform wetting of the grain can be secured with the latter type of installation.

The fan-type nozzles functioned satisfactorily throughout the testing program; however, the standard cone-type should operate successfully under many conditions (Fig. 3). The criterion for determining the proper number and type of nozzle is in the results obtained A sufficient "burn" must be obtained with a minimum of spray material. Orifice size 0.059 inch under a pressure of 35 pounds per square inch proved to be adequate and when two nozzles per hood were used, a 0.039-inch orifice size seems to be satisfactory for the chemical employed in the tests.

The speed which the unit traveled down the row was maintained at about 3.5 miles per hour. This speed was necessary to secure the required liquid coverage. The pressure, orifice size and the rate of travel must be synchronized for a given chemical to obtain proper distribution. An increase in speed would require a larger nozzle orifice for a liquid of equal viscosity. The pressure should not be increased above 40 pounds per square inch as this would tend to force the spray beyond the bounds of the hood.

PROCEDURE

Chemicals Employed

The chemical employed in these tests was Dow Contact Weedkiller, a proprietary formulation, the active ingredient of which is dinitro-o-secondarybutyl phenol. A spray consisting of 3 gallons of this formulation made up to 100 gallons with water and applied at the rate of 50 gallons per acre "burned" 8-inch grain to the crowns. The fact that the grain was not completely killed and new growth shortly appeared was considered an advantage because the crowns remained erect and provided further wind protection without the grain becoming too large to cope with. A second spray application a week or more after the first may be desirable under many circumstances; however, grain that has been allowed to re-grow for a few days after one application is easily removed by mechanical tillage equipment, because of the great reduction in volume of leafy material. Furthermore, roots rapidly decay after top growth is reduced by spraying.

The addition of extra oil to phenolic contact sprays improves the penetration of the toxicant to the growing point of the grain and a greater degree of kill can be obtained. In the 1947 tests, grain kill was improved by mixing 3 gallons of Dow Contact Weedkiller with 7 gallons of diesel oil and making up to 100 gallons. On the market now are phenolic contact-type weed killers of a concentrated form to which varying amounts of oil may be added according to the type of vegetation to be controlled, i.e. Sinox General and Dow General. If these formulations are utilized 3 pints of concentrate per 100 gallons of spray are suggested. The amount of oil with which the 3 pints of concentrate should first be mixed can vary from as little as 3 gallons if one only wishes to burn the grain back to the crown and allow regrowth for further protection to as much as 20 gallons if maximum kill is desired. Regardless of the spray mixture used, one cannot expect a complete kill if the grain has been allowed to get quite large before treatment (Fig. 4). From the practical viewpoint it would seem unnecessary to kill completely all grain inasmuch as subsequent cultivation will remove it without the difficulty encountered with unsprayed grain.

Fifty gallons of spray per acre should be sufficient for most in-

Fig. 4. Five rows of grain three days after spraying. Onions between rows of grain were uninjured. Grain in background was not sprayed.

stances in which grain is planted between each row of onions as it was in the above tests. If fewer rows are planted less spray would be required. The volume might be reduced where the grain was rather thin and especially heavy growth may require a greater volume.

OTHER USES FOR HOODS

Crops other than onions growing on muck or sandy soil have sometimes been interplanted with grain and the methods described above might prove worthwhile. In addition, other uses for such a hood might involve the application of a contact weed spray between rows in home gardens and between rows and beds in nurseries. Weeds such as purslane which are very difficult to kill by cultivation during moist weather can be killed with contact sprays.

A MORE PRACTICAL MACHINE

The chief difficulty with the experimental model was that it could not be manipulated easily on the turns. Therefore, a more functional machine might be built, placing the hoods between the front and rear wheels of a small tractor (Fig. 5). A rotary pump driven by the power

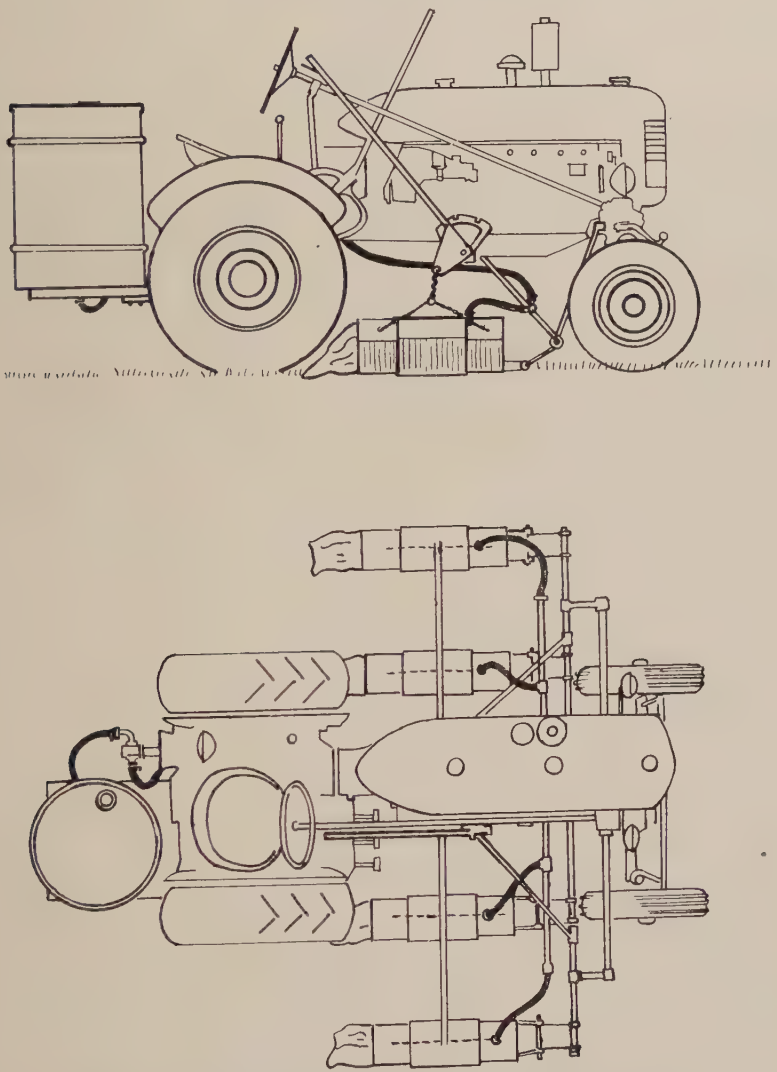

Fig. 5. A machine for chemically controlling windbreak rows in muck crops. This machine has greater maneuverability than the experimental unit.

take-off would eliminate the need for an extra engine. A 50-gallon supply tank, making use of jet agitation, would be ample for many operations. It is suggested that the raising of the hoods might be facilitated by the power lift, or attached to the tractor's integral plow or cultivator levers.

DISCUSSION

One of the advantages of chemical control of grain, planted for wind protective purposes, is the fact that the soil need not be disturbed until the crop is well established. Loose soil is more subject to blowing and if grain is planted between each row the first cultivation can be considerably delayed. Small annual weeds wet by the spray are killed. Even the dead roots and leaves of treated grain offer some protection against blowing. An added advantage is that a delay in the first cultivation means that fewer weed seeds will be brought near the surface where germination can take place. Chemical treatment of grain interplanted between each row will often reduce the total number of cultivations required. The greater wind protection afforded by more rows of grain than now employed might reduce the need for permanent windbreaks that occupy considerable land.

TAX VARIATION IN OAKLAND COUNTY AND TREND TOWARD EQUALIZATION OF TAXES BY MEANS OF ENLARGED SCHOOL DISTRICTS

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MANY PROPERTY owners seem to have a struggle, real or imaginary, to pay their taxes. To comprehend what their tax dollars purchase for many of them is an even greater struggle. The tax picture is complicated in areas of small taxing units. It tends to be even more complicated in localities of rapid population increase and ultra-rapid development of residential subdivisions, like Oakland County, much of which lies in the Detroit Metropolitan District and is in and near the so-called suburban fringe. One of the more significant aspects of the tax structure in such areas is the wide variation in size of the tax dollar, even within the same township, and within the same community. Of even greater significance is the trend toward equalization of taxes through the combination of small taxing units, which usually are school districts.

An understanding of tax variation and of possible tax equalization necessitates a knowledge of school district organization and of possible reorganization. Oakland County serves as a satisfactory unit for a study of property tax intricacies and of equalization trends, and tax and school conditions in this county are similar to those in many other counties of the state.

Oakland County lies partially adjacent to Detroit. It is composed of 25 townships, as indicated in Fig. 1 which also gives the average value of farm land and buildings per acre in 1945. According to the United States Bureau of the Census, the average value of farm land and buildings per acre in that county increased from $97 in 1940 to $133 in 1945. The average per acre in 1945 varied from $47 in Addison Township to $476 in Southfield Township. These figures are based

ARTICLE 30-45

$67 Holly	$78 Groveland	$85 Brandon	$74 Oxford	$47 Addison
$83 Rose	$88 Springfield	$124 Independence	$126 Orion	$75 Oakland
$93 Highland	$77 White Lake	$412 Waterford	$170 Pontiac	$233 Avon
$107 Milford	$151 Commerce	$184 West Bloomfield	$163 Bloomfield	$262 Troy
$121 Lyon	$148 Novi	$204 Farmington	$476 Southfield	$328 Royal Oak

Fig. 1. Average value of farm land and buildings, per acre, by townships, 1945. (Source: United States Bureau of the Census)

on market value as given by farm owners to census enumerators. Normally, tax assessors are guided by market values in determining assessments for property tax purposes. In a majority of the townships of Oakland County, the market value may have been greatly influenced by recent population increases. A special county census taken on January 28, 1947, indicates that the increase in the population between April 1, 1940, and the 1947 census date was 32.4 percent. The population growth was more than twice as great in the open-country as in the incorporated cities and villages, being 50 percent as compared with 22 percent. Among the townships with the greatest population increases during the past 5 years were Troy, Waterford, and Southfield, three out of the four townships with the highest average farm land values per acre in 1945.

Rapid population increases in small taxing units tend to boost taxes because of the need for larger school plants and more equipment, more teachers, more fire-fighting equipment, better roads, more drains, and more of all kinds of governmental services. Farmers are among the first to feel the increasing tax load, and if farm taxes rise much more rapidly than the earning capacity of these farms, some may become tax delinquent. This possibility is accentuated when the need for more parks and recreational areas takes land off the tax rolls, thus throwing additional tax loads upon the remaining farmers and property owners. All possible precautions should be taken to keep tax delinquency down. Farm land in the suburban fringe[1] tends to be uncertain and unstable so far as land use is concerned and quite vulnerable to tax delinquency. For purposes of tax analysis, it is desirable to study at least one township in considerable detail first.

TAXES AND SCHOOL DISTRICTS OF OAKLAND TOWNSHIP

Townships in Michigan are civil administrative units, each with a set of officials—supervisor, clerk, treasurer, and justices. Townships are also taxing and tax-collecting units. Of the 25 townships in Oakland County, one has the same name as that of the county and lies northeast of Pontiac, the county seat, at a distance of 2 to 14 miles. Its average value of farm land and buildings per acre was $75 in 1945, the fourth lowest among the 25 townships.

A perusal of the tax rolls of Oakland Township for 1945 shows a total of 133 pieces of property of 80 acres or more, corresponding approximately to the 124 farms recorded by the United States Census for the same year. Three of these acreages are virtually country estates and are not typical farms. They are excluded from tabulations made of the other 130 farms and listed on the tax roll as "acreages" which average 91 acres in size. Their average assessment for tax purposes was $42 per acre. The average 80-acre farm was assessed at $3,360, and the average 91-acre farm at $3,822. The average property tax per acre was 69 cents.

The property tax on the average 80-acre farm in Oakland Township in 1945 was $55.40, distributed as follows:

[1]Several studies indicate some of the problems of the "fringe" areas in Michigan, namely: "Social Aspects of Land Use Planning in the Country-Fringe: The Case of Flint, Michigan," by Walter Firey, Michigan Agricultural Experiment Station Special Bulletin 339 (1946); and "Michigan's Country-City Fringe," by C. P. Loomis, J. A. Beegle and W. Firey, *Michigan Farm Economics* (June 1946), Michigan State College Extension Service, p. 1.

$12.05	or	21.8	percent for county services
1.76	or	3.2	percent for county debt services
7.20	or	13.0	percent for township services
28.55	or	51.5	percent for school operation
5.60	or	10.1	percent for school debt services
.24	or	0.4	percent for Krohn drain
$55.40		100.0	

Some 80-acre farms in Oakland Township were assessed for less than $1,800, while others were assessed for more than $5,000. The assessed valuation of the average 95-acre farm in Oakland Township, a farm slightly larger than the average farm in this township, is $4,000. This is a convenient figure to use in this analysis of tax variation. The property tax on farm assessments of $4,000 was $65.43, distributed as follows:

$14.32	for county services
2.08	for county debt services
8.48	for township services
33.66	for school operation
6.60	for school debt services
.29	for Krohn drain

All farms in Oakland Township with the same assessed valuation paid the same number of tax dollars for the support of the county government and for the support of the township government. However, the amount paid for school operation and for school debt service was not uniform throughout Oakland Township because that township is not a single school district. In fact, the 36 square miles of Oakland Township is in 12 different school districts, each, like Oakland Township, with taxing and debt-incurring powers.

TAX VARIATION WITHIN OAKLAND TOWNSHIP

Figure 2 is a diagram of Oakland Township, showing boundaries of school districts. Within each school district the tax levy for various purposes, as well as total property tax, is listed on farm assessments of $4,000 for the year 1945. The taxes for county purposes, county debt service, and for township purposes were the same in all of its school districts, namely, $14.32, $2.08, and $8.48, respectively. The tax for school operation varied from $23.84 in three different school districts, (Eaton, Snell and Clifton) to $48.68 in No. 2, in the Bald-

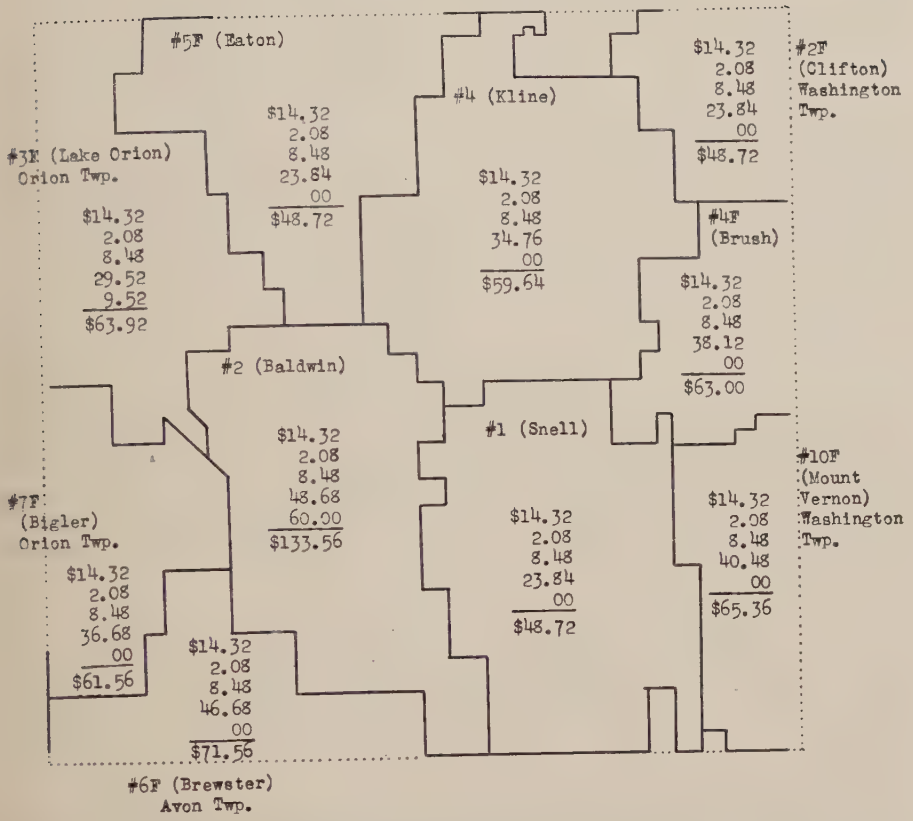


Fig. 2. Oakland Township of Oakland County showing school districts and tax levies on farm property assessments of $4,000 in 1945.

win School District.[1] Two school districts levied taxes for school debt service, in one of which it exceeded that for school operation. The total tax for all purposes on $4,000 assessments varied from $48.72 in three different school districts to $133.56 in No. 2. It is possible that the difference between $48.72 and $133.56, or $84.84, was not directly commensurate with the difference in the quantity and quality of services rendered in the different taxing units. A correct guess might be that some farmers and other property owners are carrying less than their reasonable share of the legitimate tax load, while others are carrying more than should be necessary. A combination of all the taxing units in Oakland Township would equalize the tax load. Some

[1]Two small parcels of land in Oakland Township are excluded from this analysis, namely, 100 acres in sections 35 and 36, which lie in Stony Creek School District of Avon Township, and 240 acres in sections 2 and 3, which lie in Brewer School District of Addison Township.

farmers in sections 2, 3 and 4, whose farms lie in school districts No. 4 and 5F (F indicates fractional school district, that is, lying in two or more townships) paid additional taxes in 1945 for benefits derived from the Krohn drain.

The proportion of the tax dollar going for school operation, excluding the two districts that had levies for school debt service, varied from 49 to 65 percent. The proportion of the total tax dollar going for all school purposes, including debt service, varied from 49 percent in three school districts, to 82 percent in No. 2.

If Oakland Township were one school district, the tax levy in 1945 on an assessment of $4,000, would probably have been about $65, of which approximately $34 would have gone for school operation and $6 or $7 for school debt service. However, from the viewpoint of school organization, a single school district in this township would be unsatisfactory sociologically because part of the township lies in Rochester community, a part in Lake Orion community, and a part in the Romeo community of Macomb County.

Upon completion of the eighth grade, pupils in the Eaton and Bigler School districts commonly attend the high school at Lake Orion, while those in the Brush and Clifton districts generally attend Romeo High School, and those in the other school districts of Oakland Township attend Rochester High School. For purposes of equalization of taxes and educational opportunities, high school attendance areas which possess adequate valuations and high school enrollments, merit serious considerations as taxing units. Unquestionably Rochester and Romeo high school attendance areas meet the qualifications for community school districts as stated by the Michigan Public Education Study Commission in 1943. These qualifications include, among others, that community school districts generally have at least three million dollars of state-equalized real and personal property valuations and be capable of serving adequately a minimum enrollment of 360 students from the seventh through the twelfth grades.

It will be noted from Fig. 2 that the school tax, including school debt service, is over four times as much, and the total property tax is over two and one-half times as much, in School District No. 2 as in the Snell, Eaton, and Clifton districts, with the same assessed valuations. Space limitations do not permit a similar detailed descriptive analysis of the variation in school taxes and total taxes as given in the 1945 assessment rolls in each of the 24 other townships of Oakland County.

RANGE IN TAXES IN SELECTED TOWNSHIPS

A brief discussion seems desirable of the fact that some farmers pay low taxes and others pay high taxes on property of the same assessed valuation within the same township. Table 1 lists 16 of the other 24 townships in which little or no effort had been made previous to 1945 in combining taxing units. This table shows the range in taxes for schools, including debt services, and in total property tax per $4,000 assessed valuation in 1945. Each of these townships still had five or more school districts lying wholly or largely within its borders.

There was no tax levy for school purposes in one district of Addison Township. Here the school electors apparently decided that their school balance from the previous year plus state aid based on the school census were sufficient to defray the cost of education for their few children, provided they closed their school and purchased education for them in another district.

The variation in taxes for school purposes was particularly great among some taxing units in Avon, Independence, Troy, and West Bloomfield townships. Total taxes in certain school districts of Avon, Southfield and Troy townships were higher than in the costliest tax district of Oakland Township.

A comparison of the foregoing figures in one township with those of any other would not necessarily be strictly comparable because of the difference in the assessment ratios to true values. Township super-

TABLE 1—*Range in school tax, including debt service, and in total property tax, per $4,000 assessed valuation, for selected townships, in 1945*

Township	Range in total school tax	Range in total property tax
Addison	$ 0.00 to $ 37.96	$16.12 to $ 54.08
Avon	10.80 to 124.44	56.40 to 159.24
Bloomfield	20.08 to 62.20	47.64 to 89.76
Groveland	17.12 to 34.28	38.24 to 55.36
Holly	17.04 to 43.80	39.68 to 66.44
Independence	16.44 to 80.40	41.40 to 105.36
Lyon	17.88 to 33.08	36.40 to 51.60
Novi	16.60 to 49.80	39.00 to 72.20
Orion	19.16 to 68.30	39.20 to 89.36
Oxford	24.40 to 58.40	50.80 to 84.80
Rose	18.44 to 36.89	42.54 to 60.94
Southfield	42.10 to 121.52	86.50 to 165.96
Springfield	19.72 to 39.44	40.84 to 60.56
Troy	17.36 to 102.26	59.16 to 163.16
West Bloomfield	4.76 to 46.72	30.44 to 93.68
White Lake	18.72 to 37.44	36.00 to 54.72

visors in the different townships of the same county do not necessarily assess alike, and the variation in the different townships of Oakland County in 1945 will be indicated later. Still later, by the application of the county equalization factor, these figures will be made comparable.

TAX VARIATION IN HOLLY TOWNSHIP, PER $4,000 ASSESSED VALUATION, BY SCHOOL DISTRICTS, IN 1945

Holly Township has eight school districts that lie wholly or largely within its boundary. Taxes for five purposes are uniform throughout the township. These taxes, per $4,000 assessed valuation, in 1945 were $12.80 for county purposes, $1.84 for county debt service, $4.00 for township purposes, $2.00 for fire protection, and $2.00 for library. The total property tax and the tax for school operation, and for school debt services, by school districts, per $4,000 assessed valuation, were as follows:

School district	School operation	School debt service	Total property tax
No. 1F, Stony Run	$32.00	.....	$54.64
No. 2, Newark	38.32	.....	60.96
No. 4, Five Points	21.32	.....	43.96
No. 5, Olive Branch	17.04	.....	39.68
No. 6, Holly	32.00	$11.80	66.44
No. 7, Patterson	17.12	9.50	49.08
No. 8, Willover	19.16	.....	41.80
No. 9, Traphagen	38.32	.....	60.96

All of the 36 sections or square miles of Holly Township, except for 80 acres, lie in the Holly trade and high school attendance areas. About 60 square miles in Rose, Springfield, and Groveland townships also lie in the Holly trade and high school attendance areas. A combination of the 19 school districts in the Holly community would adequately meet the specifications of a single community school district in terms of valuation and high school enrollment.

The variation in taxes for educational purposes and in total property tax is not large in Holly Township, nor in any other township in the northern part of Oakland County, as compared with a majority of the townships in the southern, eastern and central parts of the county in which phenomenal increases in population and in farm land values have been experienced, in recent years.

TAX VARIATION IN AVON, TROY, AND SOUTHFIELD TOWNSHIPS, PER $4,000 ASSESSED VALUATIONS, BY SCHOOL DISTRICTS, IN 1945

Avon Township has 11 school districts lying wholly or largely within its boundary. Taxes for four purposes are uniform throughout the township. On the basis of $4,000 assessed valuations, they are, $16.20 for county service, $2.40 for county debt service, $10.80 for township service, and $5.40 for a special fire fund. The total property tax and the tax for school operation and for school debt service, by school districts in Avon Township per $4,000 assessed valuation, in 1945 were as follows:

Number and name of school district	Tax for school operation	Tax for school debt service	Total property tax
No. 1F, Stony Creek	$10.80	.....	$45.60
No. 2F, Avon	48.60	$75.84	159.24
No. 3, Brooklands	36.20	71.84	142.84
No. 4, Hamlin	47.28	27.00	109.08
No. 5, Rochester	54.04	16.20	105.04
No. 6F, Brewster	52.96	.....	87.70
No. 7, Ross	33.48	.....	68.28
No. 8, Hubble	21.60	.....	56.40
No. 9, Christian Hill	36.72	.....	71.52
No. 10, Elmwood	43.20	32.40	110.92
No. 11F, Stiles	51.88	54.04	140.72

Rapid increase in population means increases in school enrollment, teachers, and additional school buildings and equipment. Between 1940 and 1947 the population in Avon Township increased from 8,776 to 11,067, an increase of 26 percent.

In 6 of the 11 school districts in Avon Township there was a tax for school debt service, and in three of them it was greater than that for school operation. The school districts with school debt services are in the southern half of the township in which the most rapid population growth and most extensive suburban developments have taken place.

The Elmwood and the Stiles School districts and Troy No. 10F were combined in November 1947, with the Auburn Heights School District in Pontiac Township to form a single school district. All of the other school districts of Avon Township lie in the Rochester high school attendance area. The tax for school operation and for school debt service in the Rochester School District in 1945 totaled $70.24 per $4,000 assessed valuation. This is a lower figure than in the Avon,

Brooklands and Hamlin School districts in which the tax for total school purposes was $124.44, $108.04, and $74.28, respectively. The creation of a township school district, or preferably, the organization of a Rochester community school district, would equalize the tax load.

Troy Township has nine school districts wholly or largely within its boundary. Taxes for five purposes were uniform throughout the township. These taxes, per $4,000 assessed valuation, were $15.32 for county purposes, $2.20 for county debt services, $4.04 for township drain, $12.24 for township purposes, and $8.00 for township debt service. Most of the farmers throughout the township with $4,000 assessed valuation were also taxed $19.20 for the Featherly Drain, and in one school district, No. 10F, they were taxed $8.30 for the Sprague Drain. The total property tax and the tax for school operation and school debt services, by school districts in Troy Township, per $4,000 assessed valuation, in 1945, were as follows:

Number and name of school district	Tax for school operation	Tax for school debt service	Total property tax
No. 1F, Troy-Union	$40.88	$61.38	$163.16
No. 2, Troy	49.04	42.16	133.00
No. 3F, Leonard	17.36	.....	59.16
No. 4, Troy-Smith	41.88	.....	83.68
No. 5, Colerain	38.32	30.64	110.76
No. 6, Big Beaver	35.76	30.64	108.20
No. 7, Log Cabin	49.04	35.76	126.60
No. 8, Poppleton	38.32	.....	80.12
No. 10F, Troy-Stone	35.76	30.64	116.50

Six of the nine school districts in Troy Township have tax levies for debt service, of which five are approximately equal to the tax for school operation, and in one it exceeds that for school operation. Between 1940 and 1947, the increase in population in Troy Township was 28 percent, from 8,505 to 10,921. This increase in total population gives a clue to the increased needs for additional school buildings, equipment, and teachers. In the Troy-Union School District, the school census (children ages 5 to 19 inclusive) showed 84 in May 1936, and 231 in May 1947.

Southfield Township in 1945 had 11 school districts lying wholly or largely within its boundary. Taxes for four purposes were uniform throughout the township. These, per $4,000 assessed valuation in 1945 were $23.40 for county purposes, $3.36 for county debt service, $4.72 for township drain, and $12.96 for township purposes. The total tax and the taxes for school purposes were as follows:

Number and name of school district	Tax for school operation	Tax for school debt services	Tax voted for increased school millage	Total property tax
No. 1, Old Parker	$46.80	.....	.....	$91.24
No. 1F, Franklin	49.96	$27.32	$19.52	141.24
No. 4, East Southfield	39.00	48.00	.....	131.44
No. 5, Brooks	50.72	.....	.....	95.16
No. 6, Angling Road	42.10	.....	.....	86.50
No. 7, McKinley	31.20	28.00	.....	103.64
No. 8, Brace	37.44	23.44	.....	105.28
No. 9, John Grace	46.80	40.00	.....	131.24
No. 10, Southfield	59.12	15.60	46.80	165.96
No. 11, Lathrup	41.36	17.56	.....	103.36
No. 12, Magnolia	40.44	.....	5.84	90.72

Eight of the 11 school districts in Southfield Township in 1945 levied taxes for school debt service or taxes for school purposes beyond the 15-mill tax limitation for all purposes on state-equalized valuation. This township increased 64 percent in population from 1940 to 1947, that is, from 8,468 to 13,913. Between May 1936 and May 1947 the school census total had increased in the Brace School District from 91 to 528, in Southfield School District from 151 to 555, and in Lathrup School District from 50 to 333.

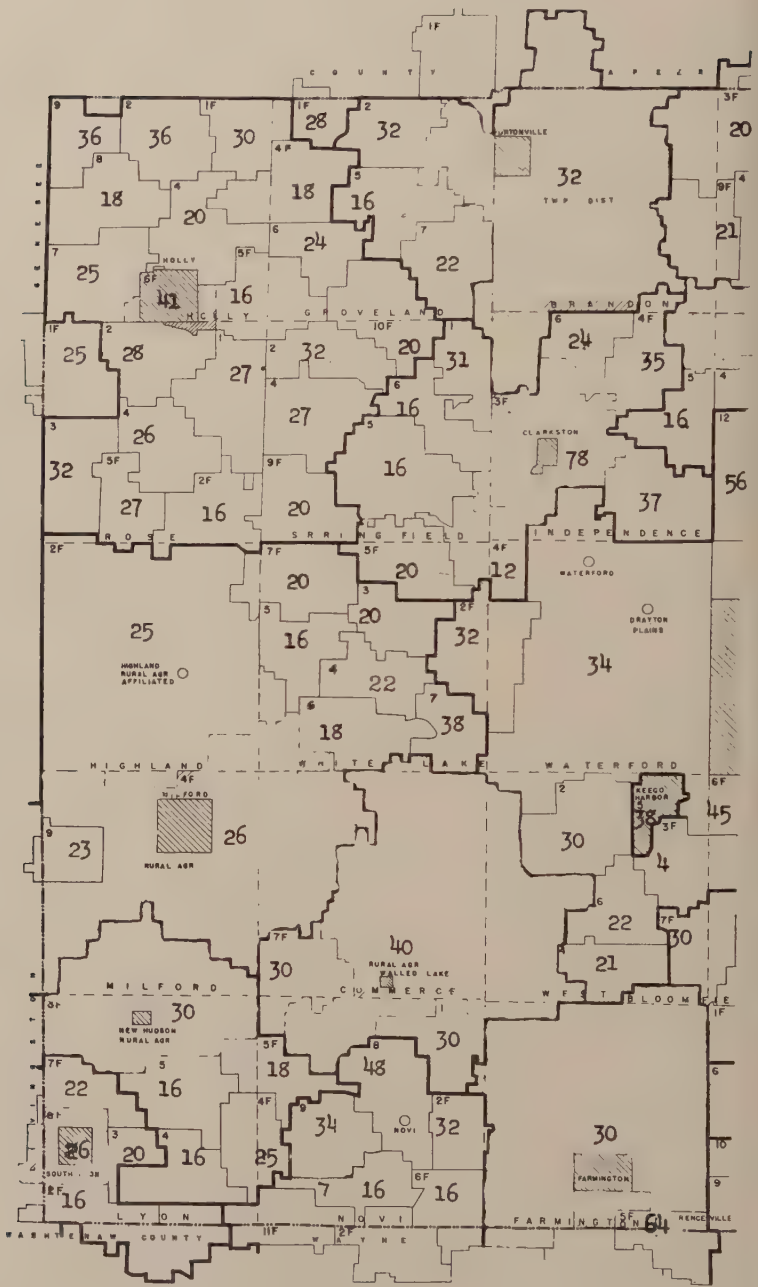
Farmers in the different school districts of Avon Township, with the same assessed valuation ($4,000), in 1945 paid property taxes of $45, $56, $68, $71, $87, $105, $109, $110, $140, $142, and $159.

In Troy Township, farmers in the various school districts, with $4,000 assessed valuations, in 1945 paid property taxes of $59, $80, $83, $108, $110, $116, $126, $133, and $163.

In the different school districts of Southfield Township, farmers with $4,000 assessed valuations in 1945 paid property taxes of $86, $90, $91, $95, $103, $105, $131, $141, and $165.

In each of the foregoing three townships, the differences in the total property tax paid by farmers with the same assessed valuations were due largely to differences in total school costs, including debt service, in the various school districts. In 1945 in three-fourths of the 141 school districts considered in this study, more than one-half of the total tax dollar went for school purposes, which included debt service and special millage for building and site funds.

The differences in costs among the school districts do not necessarily reflect corresponding differences in either the quality or quantity of curricular offerings or educational benefits. The tax load of farmers within these townships will continue to vary considerably and


COUNTY
OXFORD
TWP DIST
HOLLY
GROVELAND
BROWNDON
CLARKSTON
INDEPENDENCE
ROSE
SPRINGFIELD
WATERFORD
DRAYTON PLAINS
HIGHLAND
RURAL AGR AFFILIATED
WHITE LAKE
KEEGO HARBOR
MILFORD
RURAL AGR
COMMERCE
WEST BLOOMFIELD
NEW HUDSON
RURAL AGR
NOVI
FARMINGTON
RENCENVILLE
LYON
WASHTENAW COUNTY
WAYNE

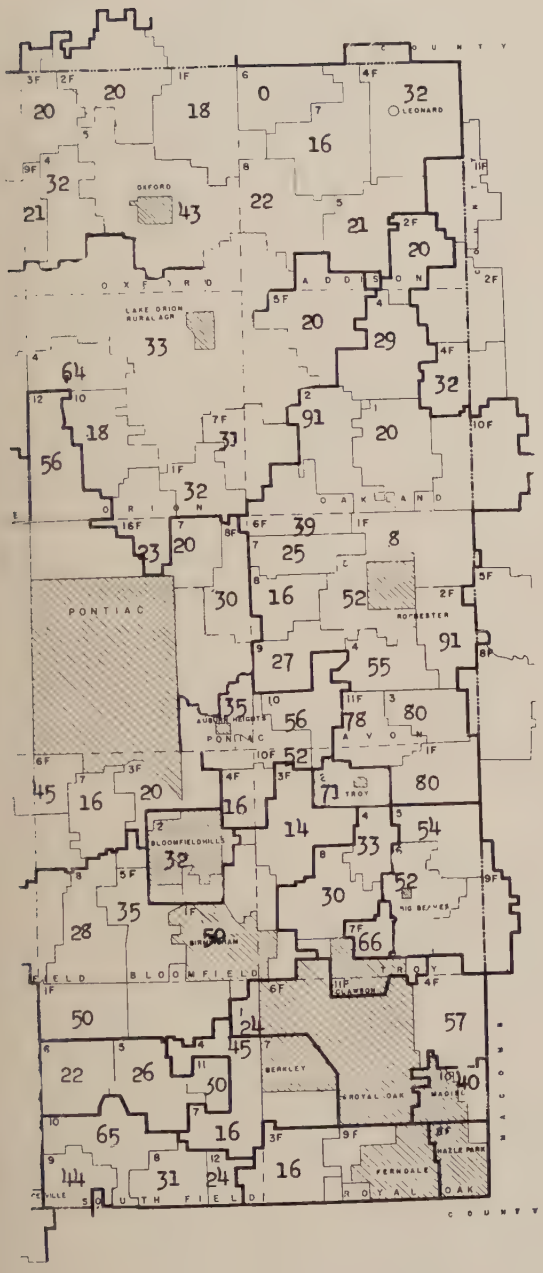


Fig. 3. Tax for school purposes, including school debt service and building and site funds, on $4,000 assessed valuation, as equalized by school districts, in 1945.

rest unduly heavy on some as long as the townships are split up into numerous taxing units, sometimes more than a dozen. Occasionally a small taxing unit may have tremendous taxable wealth and others may have very little. Chance or luck is frequently the primary reason for irregular distribution of taxable wealth. Enlarged taxing units have materially equalized taxes in the townships of Highland, Commerce, Brandon, Milford, Lyon, and Southfield, as will be indicated later.

Several times on preceding pages attention has been called to the fact that a comparison of taxes among school districts in different townships was not strictly comparable because of the differences in the assessment ratios to true value. For that reason, the Oakland County Board of Supervisors annually examine properties and compare assessment rolls of the several townships and cities within the county and equalize the same by adding to and deducting from the valuation of the taxable property in the several townships and cities so assessed, such an amount as in its judgment will produce relatively an equal and uniform valuation of the taxable property in the county. In 1945 the assessed valuation was as little as 51.3 percent of the county-equalized valuation in Southfield Township, and as much as 96.8 percent in Novi Township. The valuations as determined by the County Board of Supervisors was approximately two-thirds of the true market value in 1945.

TAX VARIATION FOR SCHOOL PURPOSES, IN OAKLAND COUNTY

Figure 3 shows for each school district in Oakland County (excluding Pontiac, Royal Oak and several other districts in which few or no farmers reside) the amount of property tax levied on assessments of $4,000 as equalized (by the County Board of Supervisors), in 1945, for all school purposes, including debt service and special millage voted for building and site funds.

On the basis of $4,000 assessment as equalized, taxes for county purposes and county debt service were uniform throughout the county, namely $12 for the support of the county and $1.75 for county debt service. No taxes were levied for township purposes in Addison Township. In the other 24 townships this figure varied from $1.02 in White Lake Township to $10.50 in Independence Township. Two townships

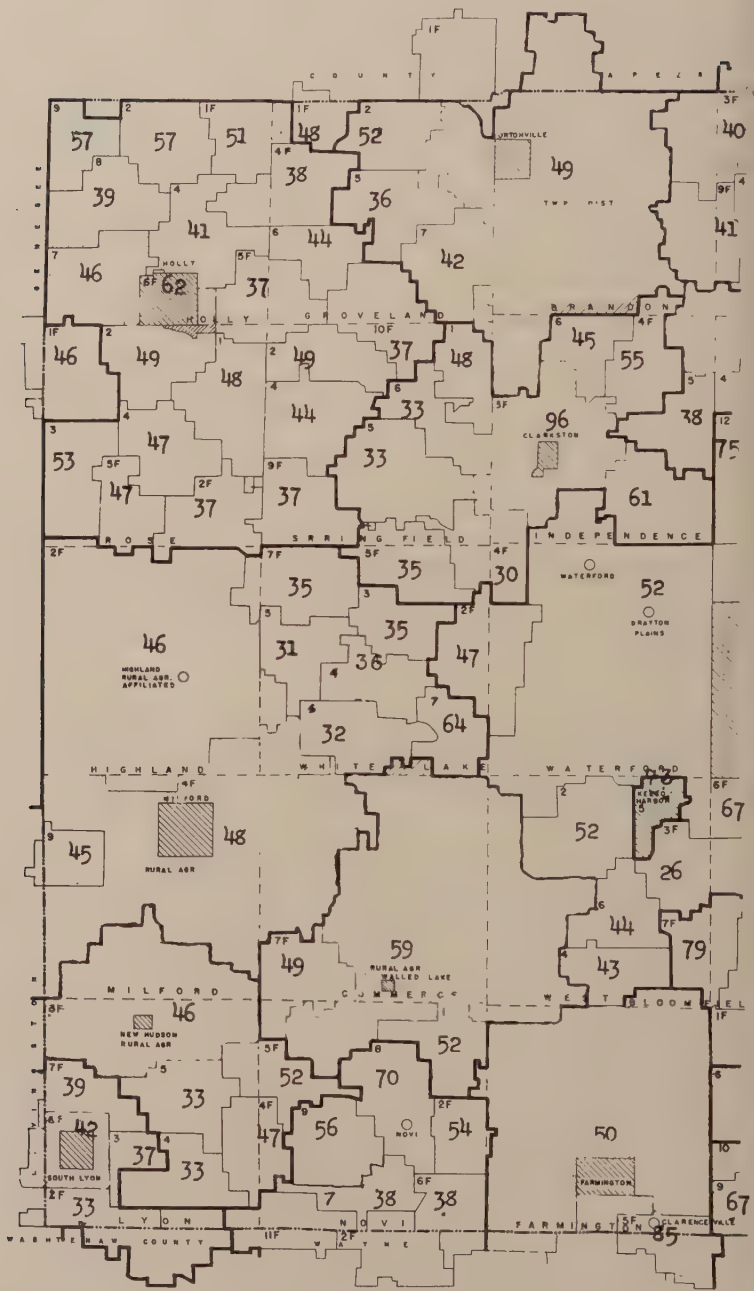
levied taxes for township debt services, namely Troy with a levy of $6.26 and Royal Oak with a levy of $8.68. Some townships also had one or more special tax levies for such purposes as drains, library, fire-fighting equipment, garage, cemetery, veterans' council, and others, which in some townships were included in the township levy.

The property tax, per $4,000 assessed valuation as equalized, varied considerably in Oakland County, namely from nothing in Addison No. 6 to $91 in Avon No. 2F and in Oakland No. 2. The range within some high school attendance areas may also be noted. These attendance areas frequently coincide with the town-country communities, or trade and service areas of villages. The range in Holly community was from $16 to $41; in Oxford community from nothing to $43; in Rochester community from $8 to $91; in Clarkston community from $12 to $78; and in Lake Orion community from $18 to $64. These differences do not necessarily reflect corresponding differences in quality of education. Combining school districts would reduce the differences in school taxes and increase opportunities for improvement in the quality of education.

TOTAL PROPERTY TAX VARIATIONS, BY SCHOOL DISTRICTS, IN OAKLAND COUNTY

Figure 4 shows by school districts in Oakland County the amount of property tax for all purposes levied on farm assessments of $4,000 as equalized (by the County Board of Supervisors) in 1945. The range was from $14 in Addison No. 6 to over $100 in seven districts, three of which were in Avon Township, two in Troy Township, one in Royal Oak Township, and one in Oakland Township. The costliest was in Troy No. 1F.

The range within some communities (high school attendance areas) may be noted, namely from $37 to $62 in Holly; from $14 to $63 in Oxford; from $34 to $128 in Rochester; from $30 to $96 in Clarkston; and from $37 to $84 in Lake Orion. The formation of community school districts would equalize these taxes as it has in eight communities and townships of Oakland County. Combination of school districts would normally increase the tax for the low tax payers, decrease it for the high tax payers, and remain unchanged for some.


HOLLY
GROVELAND
BRANDON
ROSE
SPRINGFIELD
INDEPENDENCE
CLARKSTON
WATERFORD
DRAYTON PLAINS
HIGHLAND
WHITE LAKE
MILFORD
COMMERCE
WEST BLOOMFIELD
FARMINGTON
NOVI
SOUTH LYON
LYON
WASHTENAW COUNTY
HIGHLAND RURAL ASS. AFFILIATED
RURAL ASS
NEW HUDSON RURAL ASS
WALLED LAKE

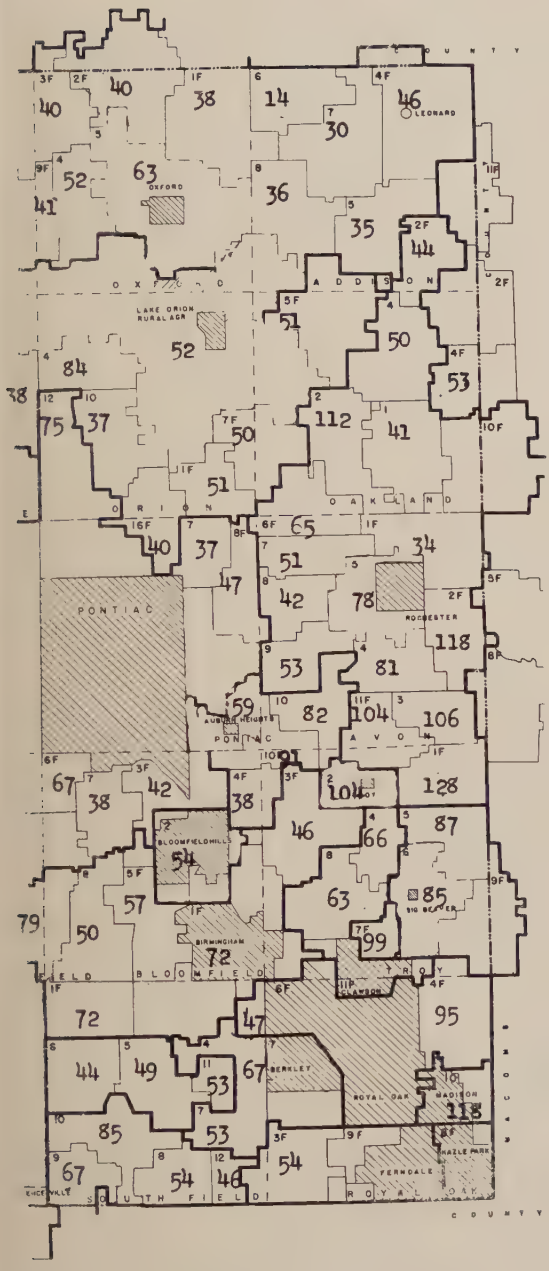


Fig. 4. Total property tax on $4,000 assessed valuation, as equalized, by school districts, in 1945.

EQUALIZATION OF TAXES THROUGH ORGANIZATION OF COMMUNITY OR TOWNSHIP SCHOOL DISTRICTS

About one-third of the farmers in Oakland County now live in areas where the tax loads have been substantially equalized. The larger areas involved in these reorganizations are indicated in Fig. 5. In Walled Lake community, in 1921, the year before the organization of its Rural Agricultural School District, a person with property assessed at $4,000 paid only $32.24 total school tax if he lived in one of the seven districts included within the merger, and as much as $62.10 total school tax if he lived in the costliest of the seven tax districts. Both districts were in Commerce Township. The difference in cost probably had little or no relation to the difference in the quality of instruction or the richness of the educational environment. The total property tax on $4,000 assessments, in 1921, in the cheapest of the seven school districts was $106.48 and in the costliest, $202.76, and both were in Commerce Township. The next year it was $165.20 for the entire area.

In Highland Township, in 1921, the year before the merger of its six school districts, farmers and property owners having property assessed at $4,000, paid school taxes which ranged from $13.32 to $33.68. This figure was $25.44 in 1922 and uniform throughout the entire combined area. The total property taxes ranged from $97.24 to $117.60 the year before the township school district was formed, and it was $97.80 for the new combined area the following year.

The Milford Rural Agricultural School District represented a seven-district merger in 1922-23 in which property owners with $4,000 assessed valuations the previous year paid as little as $9 in one district for the support of their schools and as much as $60.08 in the costliest school district, and all seven districts were lying largely in Milford Township. The figure was uniformly $51.20, in 1923, in the new, enlarged district. Just before reorganization, the total tax for all purposes was $125.80 in the lowest taxing unit and as high as $195.36 in the highest. In 1923, the tax was uniformly $173.36.

In Waterford Township, in 1941, the total school tax varied from $20 to $69.20 and the total tax from $53.92 to $103.12 per $4,000 assessed valuations, while in 1942, the year of the organization of the Waterford Township School District, the school tax was $52 and the total tax was $84.44.

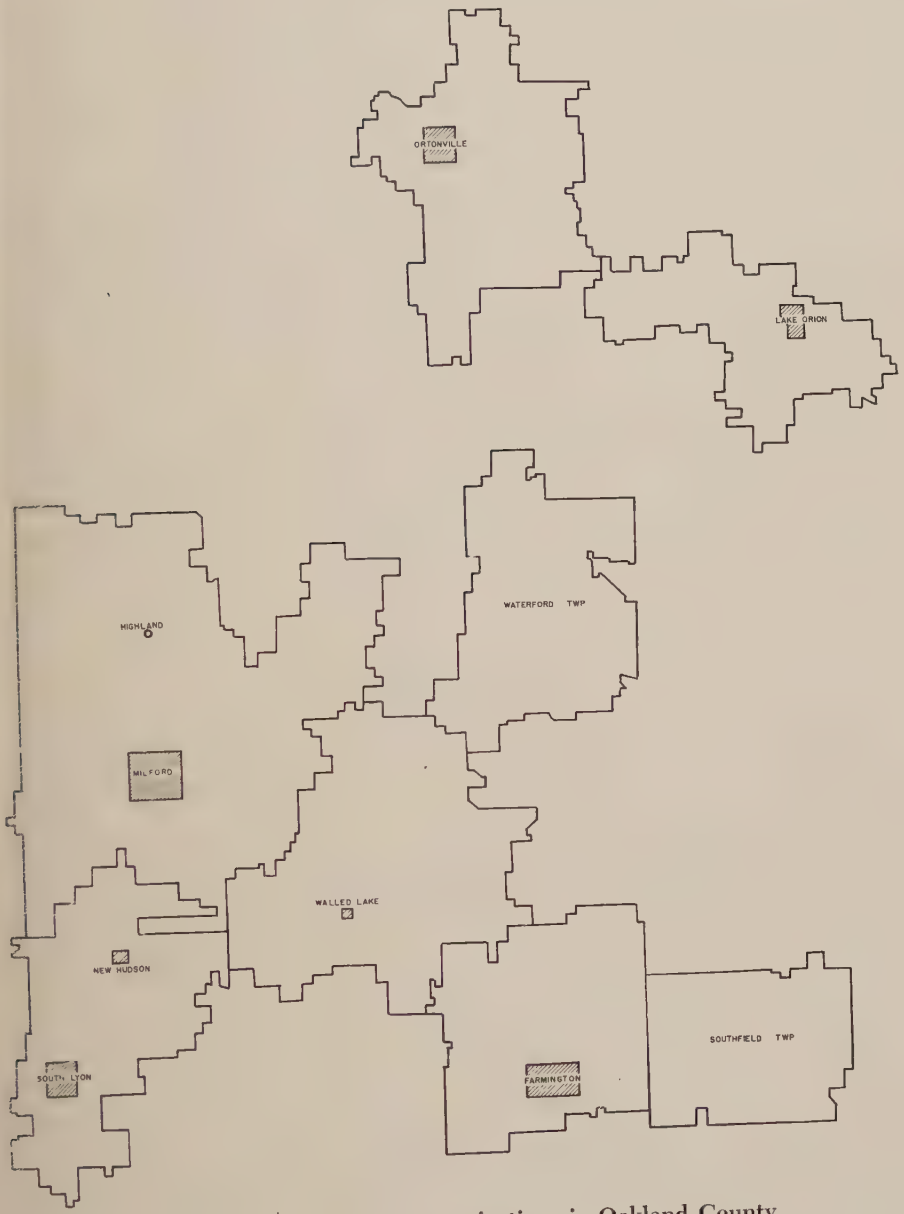


Fig. 5. School district reorganizations in Oakland County.

In 1942, in Brandon Township, the total tax varied from $11.32 to $49.32 per $4,000 assessed valuation. In contrast, in 1943, the year the Brandon Township School District was formed, the total school tax was $22.80 and the total tax was $38.32.

Similar equalization of school taxes and of total taxes took place in other school district reorganizations, such as those in the communities of Lake Orion, Farmington, Bloomfield Hills, Birmingham, Auburn Heights, and in Southfield Township. In several of these the reorganizations and annexation took place since 1945.

Many factors have induced school district reorganizations in the county. Of first importance is possibly the element of unusually able educational leadership extending over a period of at least a quarter-century. This county pioneered in school district reorganization soon after the Rural Agricultural School District Act became operative in 1919. Recently, many reorganizations have been stimulated by migrants from the city who demanded for their children the same enriched, educational environment, they had previously experienced in the larger graded urban districts. The children of long-established residents naturally benefited, educationally, from such resulting reorganizations and curriculums.

STATE EQUALIZED VALUATION PER SCHOOL CENSUS CHILD

Wealth is very unequally distributed, even within townships and communities. This is indicated, in part, by the wide variation in the amount of wealth per school child, by school districts. One school district may have many children but little taxable wealth and another may have few children but much highly restricted resort property, manufacturing plants, power dams, or other concentrated taxable wealth.

In 1941, Oakland County had as little as $851 of state-equalized valuation[1] per school census child in one district and as much as $26,933 in another district. Such a situation frequently results in an economically poor district having a high tax rate, especially for school purposes, and a wealthy district having a low tax rate. Reorganization of school districts into township school districts and into rural agricultural school districts tends to level off inequalities. However, reorganization is sometimes stymied by electors in the wealthy district refusing to participate, since it means a sharing of their taxable wealth and a raise in their light or moderate tax load.

[1]The ratio of assessed valuation to true market values varies considerably in different counties. Therefore, for purposes of distributing state aid equitably, a State Board of Equalization assigns valuations to each county.

On November 7, 1944, the electors of Farmington Township, excepting the Clarenceville School District, voted to become a single school district. In 1943, in the eight school districts comprising this union, the state-equalized valuation per school census child ranged from $1,830 in No. 6 to $10,786 in No. 1F. The next year, with a school census total of 1,807 and a state-equalized valuation of $7,611,183, the valuation per child within the township school district was $4,212.

Southfield Township School District is a recent reorganization. In 1945, the year before its organization, No. 6 had a state-equalized valuation of $3,524 per school census child, while No. 11 had $13,146, and No. 12 had $13,193. The next year, as a result of the union of these eight districts the school census totaled 3,019 and the state-equalized valuation totaled $17,308,732, or $5,733 per child.

The South Lyon Rural Agricultural School District has just been formed out of six districts, including the New Hudson Rural Agricultural School District, which was a three-district merger in 1923. In 1946, the range in state-equalized-valuation-per-school-census child in these six districts varied from $5,241 to $10,091.

The task of equalizing the tax load locally in Oakland County, despite the reduction in the number of school districts from 202 in 1920 to 121 school districts at the present moment, is less than half complete. Property owners in many localities are considering the practicability and desirability of increasing educational opportunities for their children. Proponents of school district reorganization have many followers in those sections in which inequalities are not too great. The present increase in some taxing units of tar paper shacks and basement houses filled with large families, property restrictions, and the movement of high taxable properties into other taxing units, tend to accentuate inequalities. Nobody likes to adopt an "orphan" taxing unit. Tax payers who live in "milk and honey" taxing units do not care to share their luck and taxable wealth. The tax loads of many other tax payers of this county could be considerably lightened by the formation of more township or community school districts. However, in any comprehensive reorganization of taxing units, about one-third of the property owners will experience a rise in taxes. Such tax payers are more likely to endorse and support reorganization when they are thoroughly sold on the merits of adequate equalization of educational opportunities for all children, including their neighbor's children.

SUMMARY

In 1920, Oakland County had 242 units of government, each with taxing and debt-incurring powers. On January 1, 1948, this county had 172 units of government—one county, 25 townships, 12 cities, 13 villages, and 121 school districts. Tax rates vary considerably among governmental units, especially between school districts, even within townships and communities. Such equalization of taxes as has taken place in this county was accomplished largely through the merging of 72 school districts into eight school districts and the annexation of some primary school districts to the graded districts.

Continued suburban development is very likely in Oakland County. This county is conveniently near for many Detroiters and other Wayne County urbanites who commute daily, and for many others who maintain summer homes on Oakland County's numerous lakes. Zoning can curb the development of sub-marginal housing which is a fire hazard and a health menace. This requires community enlightenment and action. Through zoning ordinances, good land might be preserved for agriculture, but to do so the owner must be lured by greater inducements than that promised by suburban real estate promoters. Also through zoning, subdivisions might be restricted to less productive agricultural areas.

A restudy of the tax equalization of all units of government in Oakland County seems desirable. The present basis of tax equalization is a Michigan State Tax Commission survey based on 1941 and 1942 figures and property sales. Since then there have been tremendous changes in amount of land in farms, in population, in new dwellings, in taxable wealth, and in government costs. According to the United States Census of Agriculture for 1940 and for 1945, all land in farms decreased about 15,000 acres in eight townships and increased about 27,000 acres in the other 17 townships, while the value of farm land and buildings decreased nearly a million dollars in three townships and increased by more than 15 million dollars in 22 townships. Considerable acreage has been taken off the tax rolls for recreational purposes in recent years. It is estimated that the Michigan State Department of Conservation and the Huron-Clinton Metropolitan Authority already own nearly 40,000 acres in the county which are being developed into parkways, new lakes, and playgrounds for the two million persons in the Detroit Metropolitan District. Such changes demand frequent revaluation of property assessments in order that they be just and equitable.

PROTECTION OF VEGETATION FROM FROST DAMAGE BY USE OF RADIANT ENERGY— PART III

By F. J. HASSLER,[1] C. M. HANSEN,[2] and A. W. FARRALL[3]
SECTION OF AGRICULTURAL ENGINEERING

THE AGRICULTURAL Engineering Department of Michigan State College has continued its development of the use of infrared radiant energy for the protection of vegetation from frost damage. Reports on previous work done in this field may be found in the Michigan Agricultural Experiment Station Quarterly Bulletins, Vol. 29 No. 2 and Vol. 30 No. 1.

The objective of the experiments during the past year was to develop an effective unit which would be a sound investment to the farmer. Many designs were considered, and the three most practical units were tested during natural frosting conditions. This is a report of three experiments with the three units.

EXPERIMENT I

Description of Apparatus

The units used for this experiment were given the designations, "Type A" and "Type B" (Fig. 1). The relative merits of each unit are given as follows: Type B gave better energy distribution than did Type A, and therefore is more efficient. Type B gave the same radiation intensity as Type A at 120 feet distance from the unit when burning only 75 percent as much fuel. However, Type B involves a greater initial investment cost, since both the material and construction costs are greater.

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[1]Instructor in Agricultural Engineering.
[2]Assistant Professor of Agricultural Engineering.
[3]Professor and Head of Agricultural Engineering.

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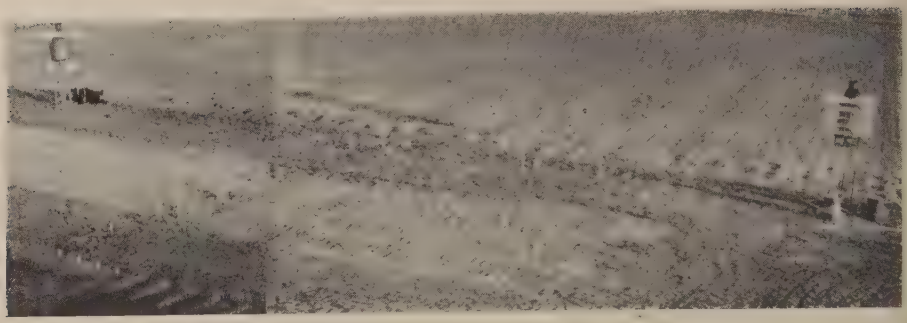


Type A Type B

Fig. 1. Type A unit at left with Type B unit on the right. This was the set-up for Experiment I.

Procedure for Testing

The weather report of October 9, 1947, predicted a possible frost for that night, and plans were made to test the units. The units were placed in an east-west direction 130 feet apart with "A" west of "B" (Fig. 1).

Potted coleus plants, taken from the greenhouse were photographed (Fig. 2), and spaced at 10-foot intervals between the units. Three plants were also set at varying distances south of the midpoint between the units (Fig. 3) in order to obtain the effect of varying distances, beyond the midpoint. The pots were placed in the ground to a depth which brought the top of the pot on a level with the ground surface. A control plant was located 300 feet east of "B". This location was beyond the effective range of the radiation. This arrangement was intended to determine the extent of area protection which the two units operating simultaneously would provide.

Radiation intensities were taken at 10-foot intervals at the ground level to a distance of 120 feet from the units.

The air temperature was taken 1 inch above the ground with mercury bulb thermometers. One thermometer was located out of the effective radiation range – alongside the control plant, while another was located at the midpoint between the units.

Fig. 2. Greenhouse grown coleus plants before Experiment I. Starting at 20 feet from A unit, the plants were taken from left to right and spaced 10 feet apart, covering the distance between the units.

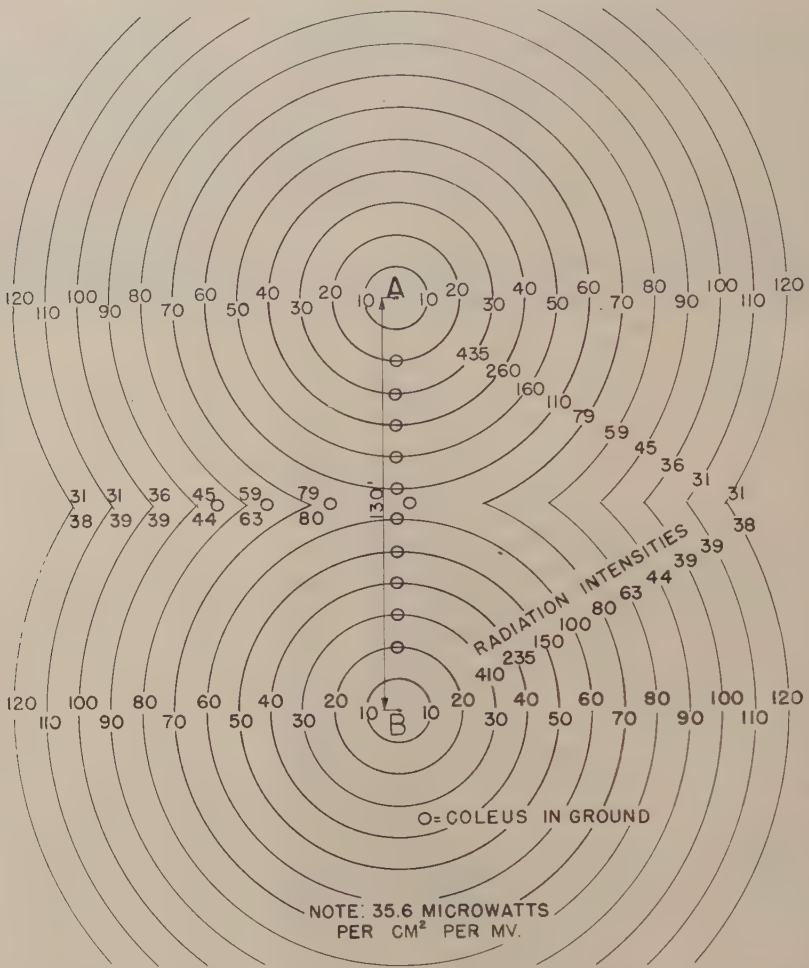
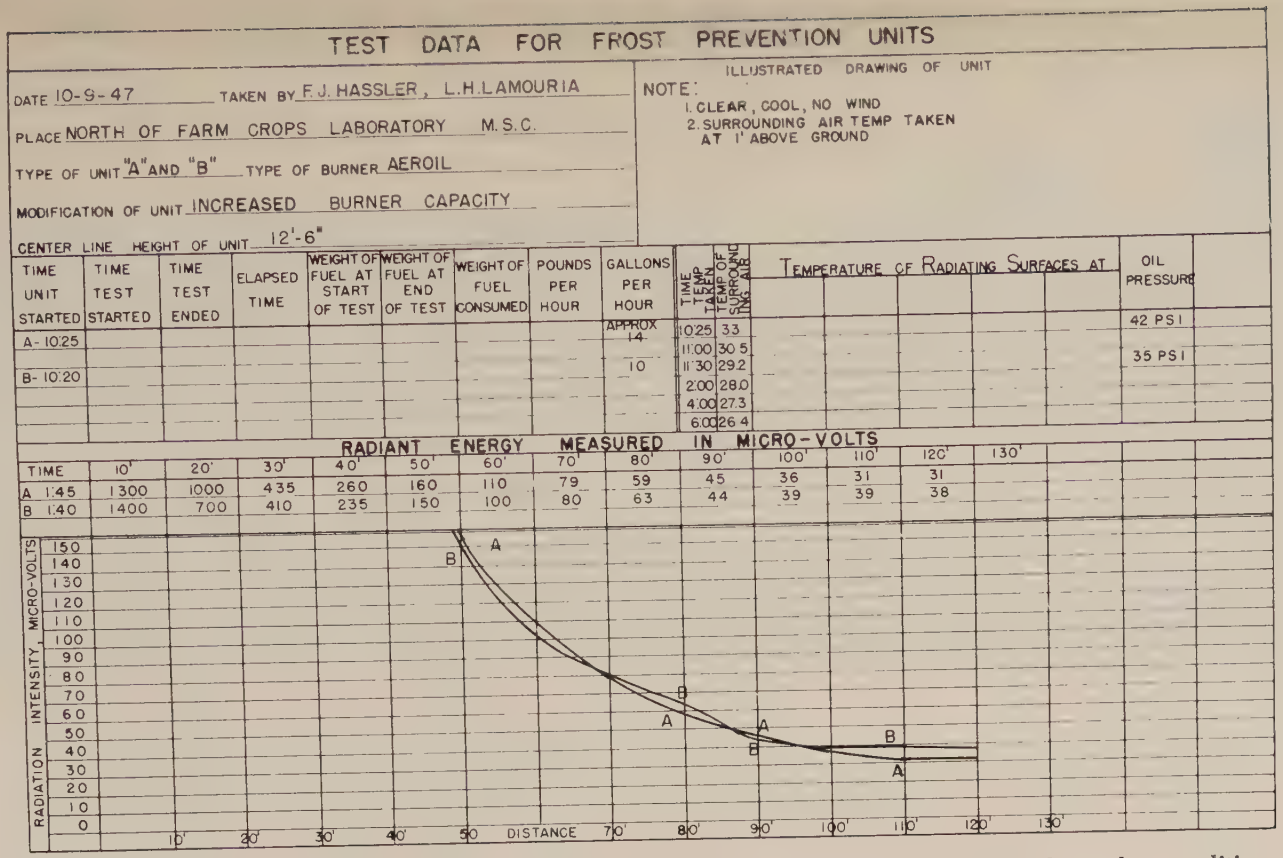


Fig. 3. Diagram of test set-up, giving distance between units, location of coleus plants, and radiation intensities in microvolts at 10 foot intervals from each unit. Note that total radiation intensity at a given point is the sum of the intensities from each unit at that point. The overlapping radiation is an important factor in the use of these units.

Data and Results

The units operated satisfactorily throughout the night without maintenance. Type A used approximately 14 gallons of fuel an hour, while Type B used 10 gallons an hour. The radiation intensities recorded in Fig. 4 are in accordance with data obtained during previous tests of these units.



TEST DATA FOR FROST PREVENTION UNITS

DATE 10-9-47 TAKEN BY F.J. HASSLER, L.H. LAMOURIA

PLACE NORTH OF FARM CROPS LABORATORY M.S.C.

TYPE OF UNIT "A" AND "B" TYPE OF BURNER AEROIL

MODIFICATION OF UNIT INCREASED BURNER CAPACITY

CENTER LINE HEIGHT OF UNIT 12'-6"

ILLUSTRATED DRAWING OF UNIT

NOTE:
1. CLEAR, COOL, NO WIND
2. SURROUNDING AIR TEMP TAKEN AT 1' ABOVE GROUND

TIME UNIT STARTED	TIME TEST STARTED	TIME TEST ENDED	ELAPSED TIME	WEIGHT OF FUEL AT START OF TEST	WEIGHT OF FUEL AT END OF TEST	WEIGHT OF FUEL CONSUMED	POUNDS PER HOUR	GALLONS PER HOUR	TIME	TEMP OF SURROUNDING AIR	TEMPERATURE OF RADIATING SURFACES AT					OIL PRESSURE
								APPROX								
A- 10:25								14	10:25	33						42 PSI
									11:00	30 5						
								10	11:30	29.2						35 PSI
B- 10:20									2:00	28.0						
									4:00	27.3						
									6:00	26 4						

RADIANT ENERGY MEASURED IN MICRO-VOLTS

TIME	10'	20'	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'
A 1:45	1300	1000	435	260	160	110	79	59	45	36	31	31	
B 1:40	1400	700	410	235	150	100	80	63	44	39	39	38	

Fig. 4. Test data, giving operating performance for both Type A and Type B units and weather conditions during the test.

TABLE 1—*Recorded temperatures in ° F.*

Time	Position 1 Midpoint between units	Position 2 300 Feet east of "B" unit unprotected control position
10:25 P.M.	34	33
10:45 "	35	31
11:10 "	37.8	30.4
1:15 A.M.	34	28
2:15 "	34	28
3:15 "	34	27.5
4:00 "	34.1	27.3
5:35 "	33	26.5
6:15 "	31.5	26.4
7:00 "	34	32

A review of the temperatures tabulated in Table 1 gives the minimum air temperature as 26.4° F. The thermometer which was located at the midpoint, indicated temperatures as much as 7.5° F. higher than the temperature recorded at the control plant. A thick mat of blue grass sod covered the entire area over which this test was made.

Previous tests showed that when there was a grass covering, the air temperature was lowest at the ground and increased rapidly up to a height of one foot. Above one foot the air temperature gradually approached the general air temperature. The reverse is often found to be true for open or bare ground.

Investigations by Schilling *et al.* have determined that air temperature for a specific location may vary as much as 10° F. within a few seconds. However, the mercury bulb thermometer will not react to these rapid temperature changes and for this reason the temperature registered by this type of thermometer will be the average temperature for a short period.

The extent of the protection given the coleus plants and the surrounding blue grass was obvious with the coming of dawn. For the area, other than between the units, complete protection was noted on the grass to a distance of 50 feet with evidence of some protection out to as far as 150 feet. There was no frost on the grass between the units except for a few spots at the midpoint between the units where the grass had been crushed flat by walking and did not receive many of the direct rays.

Fig. 5. Coleus plants after exposure. These were spaced at varying distances from the A unit up to the mid-point between the units. The coleus on the right was the control plant, set 300 feet east of B unit. Note the damage to this plant. Note that all of the plants which were subject to the radiation were undamaged. Plants at 40 and 50 foot distances appear different in the photo due to angle of photography but, leaves and stems actually were undamaged.

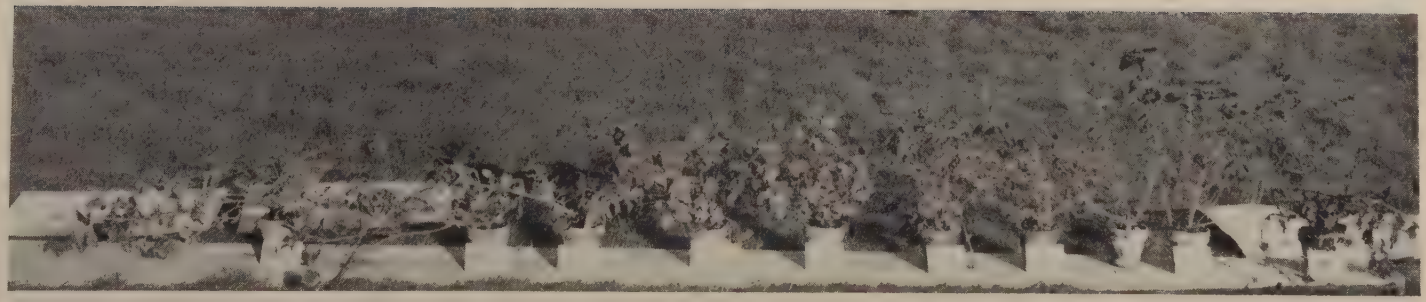


Fig. 6. Coleus plants after exposure. These plants were located between the mid-point and the B unit including those plants that were placed south of the mid-point to a distance of 90 feet from each unit. The plant at the extreme right is the control plant. Note the frost damage on that plant. The other plants were undamaged.

The coleus plants which were placed at an angle from the direct line between the units but within 90 feet of them (Figs. 5 and 6) were completely free from frost except for the bottom leaves of the plant located at 90 feet from each unit (Fig. 3). These leaves were touching the ground. The control plant was frosted to a height of 16 inches with the severity of frost formation decreasing with elevation.

Discussion

The results of this test were encouraging from two standpoints: first, the units operated satisfactorily without maintenance for a period of 8 hours; second, vegetation was protected over a large area. However, these results are for only one set of weather conditions over a particular type of ground covering and since both of these factors greatly influence the results, it will be necessary to test the units under several conditions before a full evaluation can be made. The following conclusions are drawn from a consolidation and analysis of observations taken from this test and previous tests.

1. Units operating alone gave complete protection to blue grass to a distance of 50 feet, with noticeable protection to standing grass to a distance of 150 feet; however, frost will form as close as 35 feet on grass which has been injured by flattening.

2. Sensitive coleus plants were protected in the area between the two units. Plants placed on a line at right angles to the midpoint and measuring 90 feet from each unit, were also protected, while the control plants were severely damaged.

3. When the ground is covered with vegetation such as grass, the air temperature will be lower at the ground during periods when weather conditions permit radiation losses. Also, the ground supplies only a small amount of heat to vegetation that is growing above the grass. This indicates that more radiation would be needed for this set-up than when much bare ground was exposed.

4. It is reasonable to believe that satisfactory protection would be afforded with units spaced further apart, when more than two units are operating simultaneously due to the overlap of radiation from the different units.

EXPERIMENT II

Purpose of the Experiment

Following the conclusive evidence that infrared radiant energy was effective as a means for large scale protection of vegetation from frost damage, it was decided to turn attention to the development of a unit that could be manufactured and sold at a cost which would be economically feasible. Since the intensity of radiation increases as

Fig. 7. Type AA unit with accessories. This unit operates at higher temperature than A or B units.

the fourth power of its absolute temperature, a logical improvement would be to operate at a higher temperature, making it possible to cut down the radiating surface, and still retain the effective area coverage. Owing to the excessive rate of oxidation for plain steel it was necessary to use a heat-resistant alloy to withstand the anticipated temperatures.

Description of Apparatus

A unit was constructed of aluminized steel and having only one-half the effective radiating surface area of the original Type A unit. This unit was designated as Type AA (Fig. 7). A test was made on this unit to compare its operating characteristics with the original Type A unit. The results of this test proved that the energy distribution pattern and intensity were comparable to the Type A unit when burning fuel at the rate of only 10 gallons an hour as compared with 14 gallons an hour for the original unit.

Procedure for Testing

On the night of November 14, 1947, units AA and A were set up on an east-west line with AA unit 130 feet east of A unit. The units were placed on the blue grass plot as described in Exp. I, alongside a freshly seeded wheat field. Greenhouse grown tomatoes, begonias, and geraniums were potted and placed at predetermined locations. A diagrammatic set-up is illustrated by Fig. 8. Control plants were located 350 feet west of Type A unit.

The units were put in operation after the air temperature had fallen below 30° F. The units were started and brought to the maximum temperature. The plants were then taken from the greenhouse and placed in the test area as shown in Fig. 8. The plants were exposed for two hours to allow them to reach a temperature equilibrium, after which they were returned to the greenhouse.

Air temperatures were taken with mercury bulb thermometers at intervals throughout the duration of the test. These temperatures were taken at varying elevations above the ground over a blue grass covering 350 feet west of A unit (Table 2).

Radiation intensities were taken at 10-foot intervals on the ground to a distance of 120 feet. An optical pyrometer was used to determine the surface temperature of the units. This was a total radiation meter calibrated for black body conditions.

The average wind velocity was determined over a 5-minute period.

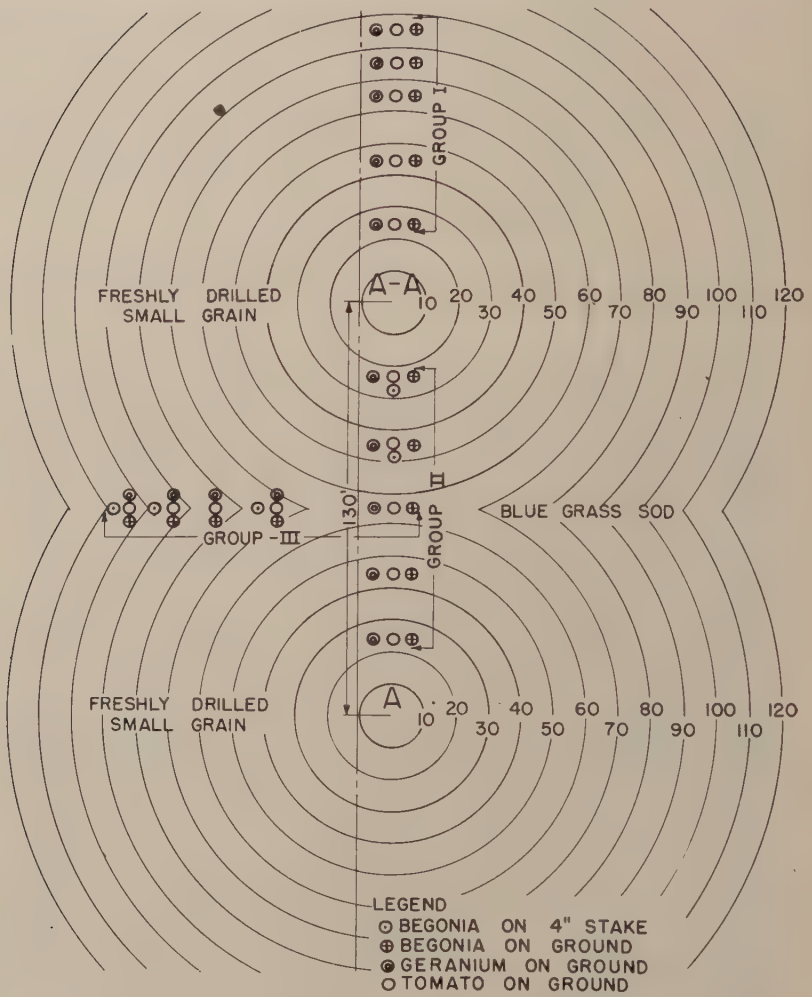


Fig. 8. Diagram of test set-up, giving location and grouping of plants for test on November 14.

TABLE 2—*Air temperature at 350 feet west of "A" unit*

Time	1 Inch above ground	2 Feet above ground	4 Feet above ground
9:15 P.M.	29.5° F.	30.0° F.	31.0° F.
10:00 "	29.4° F.	30.0° F.	31.0° F.
11:00 "	30.5° F.	31.5° F.	32.5° F.
12:00 "	32.0° F.	33.0° F.	33.5° F.

Data and Results

The sky alternated between slightly overcast and clear. An average 10-m.p.h. wind coming from the east prevailed throughout the test. These conditions reduced the likelihood of frost formation since radiation loss is slowed down by the clouds and the wind hinders condensation of moisture on the plants. Table 2 gives a maximum air temperature difference of only 2° F. between 1-inch and 4-feet elevations. This difference is much less than previous tests indicated for a grass-covered area. This small difference is ascribed to the prevailing weather conditions. The wind affected the operating characteristics of the burner, causing excessive cooling on the windward side. This resulted in lower radiating intensities and non-uniformity in the heating of the radiating surface as compared to previous tests.

At 1 inch above the ground the air temperature decreased until 10:00 p.m. at which time a low of 29.4° F. was reached. Following this the temperature began a gradual rise reaching 32° F. at 12:00 midnight. The plants were exposed from 10:00 p.m. to 12:00.

Observation of the plants the following day revealed that none of them had been frozen. Even the control plants were in as good condition as before the test.

Discussion

This test was of no consequence as far as securing information which would serve to aid in determining the area protection that the units would give. However, the results do throw further light on the relationship between weather conditions and likelihood of frost damage to plants under certain conditions. Based on this test the following conclusions can be drawn:

1. Neither tomato, geranium nor begonia plants will freeze when the minimum air temperature is 29.5° F. if the sky is slightly overcast and accompanied by a 10-m.p.h. wind.

2. A 10-m.p.h. wind affects the uniformity of heating of the radiating surface of the type of units tested. This is caused by excessive cooling of the windward side and the blowing of the flame at the initial point of combustion.

3. The new radiation unit operating at a temperature of 1,500° F. gave approximately equal radiation to the old low temperature unit operating at 1,000° F. and having twice the radiation surface. The oil consumption was reduced from 14 gallons an hour to 10 gallons an hour.

EXPERIMENT III

Purpose of the Experiment

The results of Experiment II did not provide sufficient information as to the effectiveness of the units. For that reason plans were made to make another test even though it was late in the fall and the temperatures likely to be experienced would be considerably lower than those from which the agriculturist would normally have to protect his crops.

Type A and AA units were used for this test as in Experiment II. No modifications had been made on either unit following Experiment II.

Procedure

The weather report on November 20, 1947, gave a noonday temperature of 40° F. and predicted a clear sky for the early part of the night. Plans were made to test the same units as in Experiment II with an identical layout (Fig. 8). The air temperature had fallen to 36° F. at sundown and it was evident that low temperatures would be experienced shortly thereafter. Preceding this test there had been several days and nights of sub-freezing weather and the ground had been frozen to an appreciable depth.

The tomato, begonia, and geranium plants used in this test, were photographed immediately preceding the test. Similar shots were taken following the test. The plants were grouped as to their relative position with respect to the heating units (Fig. 8). Group I was made up of those plants east of AA unit, Group II was those plants between the units and Group III consisted of the plants that were placed on a

TABLE 3—*Air temperature in ° F.*

Time	1			2	3
	1 Inch	1 Foot	2 Feet	1 Inch	1 Inch
8:30 P.M.	19	27	29.4		
8:55 "	20	28	29		
9:15 "	22	29	30.5	16	19
9:45 "	22	28	29.5	18	20.5
11:00 "	27.5	31.5	33	22	20.5

Temperature in °F.
Location: 1— 325 Feet west of "A" unit in grass cover.
2— 300 Feet southeast of "AA" unit in grass cover.
3—1500 Feet southeast of "AA" unit in stubble.

line perpendicular to the midpoint of the line connecting the units. Groups I and II were placed over a blue grass sod with grass blades to a height of 4 inches, while most plants of Group III were setting in open or fallow ground that had sparsely drilled wheat growing on it. The air temperature was taken with mercury bulb thermometers at 1 inch above the ground at three widely separated points (Table 3). Also the air temperature was taken at 1- and 2-foot elevations at one of these locations.

The units were started at 8:15 p.m., at which time the air temperature was noted to be 19° F. at 1 inch above the ground on the blue grass sod. The plants were exposed from 8:45 p.m. to 11:05 p.m. and were returned to the greenhouse. The surface temperatures of the units were taken with an optical pyrometer which was the same one used in Experiment II.

Data and Results

The air temperatures as given by Table 3 are significant in the pointing out of the temperature variation at different locations and the temperature difference associated with elevation. As previous experiments indicated, the air temperature over blue grass is lowest at the ground and rises sharply with an increase in elevation to the height of one foot. Locations No. 1 and 2 were over blue grass with the elevation of the ground surface at 2 approximately 3 feet higher that at 1. Location 3 was approximately 3 feet above location 2 and the plot was covered with a small grain stubble. The sky was perfectly clear with a slight drift in the air from east to west. These conditions were ideal for a high rate of heat loss from plants and ground by radiation; however, the air temperature was on a gradual increase throughout the test which is unusual for those prevailing weather conditions. This increase in air temperature is attributed to the drifting air since the usual trend is for the air temperature to decrease due to the radiation. Since points 1 and 2 of the temperature table were located on opposite sides of the test plot—2 being east and 1 west of the plot—an average of these two should give the approximate air temperature surrounding the plants which were located over the blue grass.

The results of this test are illustrated by the accompanying photographs. Each group consists of two photos, one taken before the test and one following. Figures 9 and 10 show plants of Group I, which were setting on the blue grass east of AA unit and received radiation

Fig. 9. Group I—Tomato plants before exposure to be located at indicated distances east of AA unit. Check plant to be located 325 feet west of A unit.

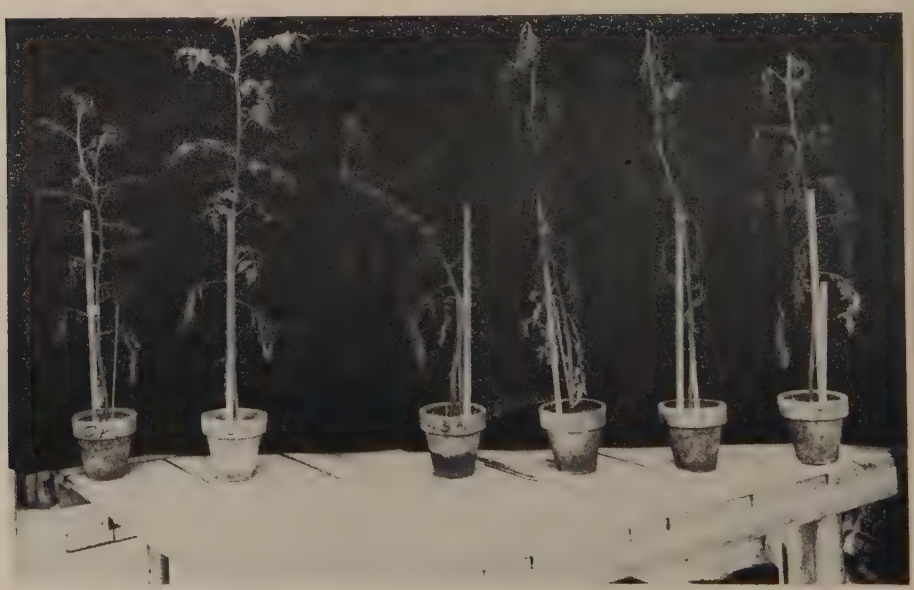


Fig. 10. Tomato plants of Fig. 9 after exposure. All plants were located over bluegrass and received radiation from one side only.

Check 25′B 45′B 65′ 45′A 25′A

Fig. 11. Group II—Tomato plants before exposure to be placed between the units. The plants were placed from A unit starting at the left, excluding the check plant.

Check 65′ 75′ 85′ 95′ 105′

Fig. 12. Tomato plants shown in Fig. 11 after exposure.

from one side only. The numbers on the pots represent the distance in feet from the unit. The results indicate that the range of protection is less than 45 feet for one unit operating alone under these conditions. Figures 11 and 12 describe the plants in Group II. This group was located between the units where the ground was also covered with a solid growth of blue grass. The numbers give the distance from the units. Those numbers followed by the letter A are the distance from the AA unit while those followed by B signify the distance from the A unit. The plant marked 65 was located at the midpoint between the units. These photographs indicate that partial protection was afforded at 45 feet from the units for the area between the two units when spaced 120 feet apart.

Figures 13 and 14 represent Group III which illustrate an interesting phenomenon. From Fig. 8 it is noted that these plants are on a line perpendicular at the midpoint of the line connecting the units.

Fig. 13. Group III—Tomato plants before exposure to be placed on a line north of the mid-point equidistant from each unit. Includes the check plant and the plant located at the mid-point (pot marked 65). The numbers on the pots indicate the distance from each unit.

Fig. 14. Tomato plants shown in Fig. 13 after exposure. The plant at the mid-point (65) and the check plant were setting in bluegrass. All others were placed over open ground. Note the protection given plants at 75 and 85 feet, the severe damage to the plant at 95 feet, and the protection given the plant at 105 feet.

They extend into the freshly seeded plot of wheat. The control plant was out of the range of effective radiation while the pot marked 65 was at the midpoint between the units. Both the plant at 65 feet and the check plant, were located in the grass sod covering. The numbers on the pots indicate the distance in feet from each of the units—being equidistant from the units. The photographs point out that there were factors involved which affected the extent of protection other than the distance from the units. The reason for the plant at 65 feet freezing, while those at a greater distance did not, may be attributed to the difference in ground covering. This cannot be true for the plant at 95 feet since it was in the same plot as the plant at 105 feet.

The begonias and geraniums gave the same results. This rules out the possibility that the plant at 95 feet was less resistant, since the probability of three different plants having low resistance at the same point is not likely.

Discussion

The results of this test were informative and showed several unusual results.

This test was made under weather conditions which would not be considered as representative of the conditions during which damage would occur to Michigan crops. However, the results do bring out some interesting observations which would be applicable under natural conditions.

The primary concern of vegetable and fruit growers in this region is for protection against frost damage shortly after the planting and the budding season and for a few weeks before the end of the normal growing period. Freezing at these periods would be expected to be less severe since the sun has released more heat during the day, storing more heat in the ground and surrounding objects, which would carry plants through the night without their reaching as low temperatures as occurred in this experiment. Previous investigations have shown that the temperature of leafy vegetation might fall as much as 10° F. below the surrounding air temperature during a night. Under the conditions of this test this difference could be expected to be greater. The ground and surrounding objects were cold at the end of the day and could not provide any appreciable amount of heat for the plants. Also, there would be a lag between the plant and air temperature since the plants cool the surrounding air early in the evening, while the air would be warming the plants the latter part of the test. Both counts would favor a greater temperature differential between the two, with the plants being the lower since there is definitely a lag in the heat transfer. This would indicate that the surrounding air temperature would not be a fair basis for determining even an approximate temperature for leafy vegetation on clear nights.

It is of note that the plants at 105 feet from the units were not damaged, while those at 95 feet showed considerable damage in this experiment. There is no simple explanation for this result, but it may be that it was due to a difference in the radiation intensity at the two points as a result of imperfection in the radiation units, or more likely it may have been due to the presence of air currents set up by the difference in temperature of the bare ground and the grass-covered areas.

Regardless of the foregoing results it seems that for a clear, calm night, less artificial heat is needed to protect vegetation over an open ground as compared with vegetation that is located over ground

which is covered with a thick mat of grass or similar growth. This may be true only when the ground is carrying a maximum of heat as in the early fall; however, the same should be true when the night was preceded by a day or more of sunshine. If the bare ground is exposed it will absorb the heat during the day and release it at night. When plants cover most of the ground they reflect or absorb the sun's heat to a limited extent allowing little to reach the ground. During the night the plants lose their heat rapidly since they are good radiators and because their heat capacity is limited. Thick, low-growing vegetation would also prevent the ground's heat from reaching vegetation which would be growing above it.

The reasoning above is supported by results of an experiment made in September on tomatoes that were growing in rows. The ground was practically free of weeds and the tomatoes were comparatively short and were spread out in such a way that a maximum of the ground was exposed. The night was clear and ideal for radiation. On this particular night the vegetation started freezing from the top and was not frozen near the ground. This is in contrast to all the tests performed over grassland, where the results showed that freezing started at the ground level and progressed upward. The exposed ground plays an important part in causing this complete reversal in results.

GENERAL SUMMARY

The problem of adapting infrared radiant energy to a method for frost control is complicated by the variance in weather conditions. The type of vegetation coupled with the topographical surroundings and the extent of associated vegetation are also important factors.

A review of the conditions and results of the three experiments are as follows: Experiment I was made when the minimum surrounding air temperature was 26.4° F. The normal temperature inversion would give the air temperature at 1-foot elevation as approximately 30° F. A check of the control plant (Figs. 5 and 6) indicates that freezing damage was done to the coleus plant at this elevation. The plant was damaged to a height of 16 inches. The plants were exposed for 8 hours, and based on known plant-temperature relationships, it would be reasonable to assume that the plant temperature was 8 to 10° F. lower than the surrounding air. Under those conditions, the coleus plants were protected in the area between the radiation units at a distance of 90 feet from the units.

Experiment II indicated that coleus plants will not freeze when the surrounding air temperature is 29.4° F. if the sky is slightly overcast and accompanied by a 10-m.p.h. wind. Under these conditions the surrounding air temperature would approximate the plant temperature owing to the reduced radiation loss and the higher film coefficient for heat transfer.

This experiment also indicated that the radiation unit operating at 1,500° F. was much more efficient than old style units which operated at about 1,000° F.

Experiment III was preceded by several days of sub-freezing weather low enough to have frozen the ground surface. On the day preceding the experiment, the air temperature ranged from 36° to 40° F. Under these conditions plants froze within 45 feet of the units when the surrounding air temperature was 29° F. at the 2-foot elevation. This was accompanied by a ground level temperature of 17° F. Figures 13 and 14 give evidence that open ground reduced the need for artificial heat.

These experiments point out the possible variable conditions of the air temperature within a few feet of the ground and that the surrounding air temperature is not an accurate indication of plant temperature under conditions favoring radiation type frosts.

The results of Experiment I should be given primary consideration since the prevailing weather conditions and the time of year chosen make these conditions representative of those under which artificial protection would most likely be needed. The positive protection obtained in this experiment indicates the possibilities of radiant energy as a practical means for frost control. The limitations, as to effectiveness of this method, will be determined by weather conditions as well as the type of vegetation to be protected and its surroundings.

Type AA unit, owing to its low cost of construction, offers possibilities of being a practical unit for manufacture and distribution commercially. However, before this is attempted on a large scale, further tests should be made, under as many varying conditions as feasible, to fully establish its limits as a practical apparatus for frost control. There will be conditions under which only partial protection will be afforded. The extent of the protection, the value of the crop saved, and the cost of the operation, will be the determining factors as to when and where it will be a profitable method of frost protection for farmers.

BULLETIN REVIEWS

Special Bulletin 341

Price Difference Among Markets for Michigan Slaughter Hogs

Stark, D. H. and Madnick, M.

A comparison of the Buffalo, Detroit and Chicago markets from the viewpoint of services rendered and prices paid. (37 pp., 6 tables, 6 figs.)

Special Bulletin 343

The Grain Storage Situation in Michigan

Motts, G. N.

This bulletin presents an inventory of the facilities for the commercial storage of grain in Michigan, compared with figures on grain production and the need for storage at different periods of the year within the same area. Some suggestions and recommendations are made for making the best use of available facilities. (58 pp., 19 tables, 19 figs.)

Circular Bulletin 206

Apple Juice Preparation and Preservation

Marshall, R. E.

A detailed explanation of the various processes involved in the making of apple juice, its blending, clarification and preservation. Suggestions are given on processing plant layout. It is written primarily for the commercial processor. (68 pp., 2 tables, 31 figs.)

Circular Bulletin 207

The Role of Minerals in the Dairy Ration

Huffman, C. F.

This bulletin presents in popular form information on the place of supplemental mineral feeds in the ration of dairy cows that are fed on Michigan-raised grains and forage. Cobalt deficiency is rather common in Michigan; phosphorus and iodine deficiency are of less frequent occurrence. (19 pp., 10 figs.)

JOURNAL ARTICLE ABSTRACTS

Soil Management for Potato Production

Tyson, J.

The American Potato Journal. 22 (9): 267-275. 1945. [Journal Article 761 (n. s.) from the Michigan Agricultural Experiment Station]

Potato production following timothy hay that had been fertilized annually with high-nitrogen mixtures was greater than that following either alfalfa, red clover, or alsike clover that had been fertilized with equal amounts of 0-14-6 grade. The yields were higher on the timothy plots fertilized with 10-6-4 than on those that were fertilized with ammonium sulfate supplying an equal amount of nitrogen, although 500 pounds of 4-16-8 fertilizer was applied for the potato crop.

Large applications (800 and 1,200 pounds per acre) of 0-14-6 fertilizer to alfalfa in the rotation resulted only in slight increases in yields of potatoes following alfalfa, the yields being 307.8, 314.6, and 316.5 bushels an acre, respectively, for the 400-, 800-, and 1,200-pound applications. However applications of large amounts of 10-6-4 annually to the timothy hay crop were accompanied by large increases in potato yields following timothy. The yields for no treatment, 400, 800, and 1,200 pounds of 10-6-4 per acre (applied to the hay crop annually) were 276.1, 319.7, 340.2, and 381.2 bushels an acre, respectively.

A rotation of corn, oats, clover, and potatoes in which the clover crop was cut for hay in June and 8 tons of manure per acre applied was more effective in producing potatoes than the same rotation with the clover and rye crop plowed down as green manures. A 3-year rotation of corn, oats seeded to clover, plowed down in spring for potatoes was least effective in producing potatoes. The average yields for four years were 168.5, 142.9, and 114.0 bushels per acre, respectively.

Evaluation of Carotene Content of Fresh and Cooked Spinach

Porter, T., Wharton, M. A., and Bennett, B. B.

Food Research. 12 (2): 133-141. 1947. [Journal Article 774 (n. s.) from the Michigan Agricultural Experiment Station]

In the home cooking of spinach there is often an apparent increase in carotene content over the amounts present in the raw material. This is explained as not being an actual increase but is due to the difference in the solid contents of the fresh and cooked products. Including the solids from the cooking water in the total solids of the cooked spinach accounted for only a portion of the difference.

Alternaria Blight and Seed Infection, a Cause of Low Germination in Certain Radish Seed Crops

McLEAN, D. M.

Jour. Agr. Res. 75 (2): 71-79. 1947. [*Journal Article 820 (n. s.) from the Michigan Agricultural Experiment Station*]

Low germination of certain radish seed crops in Michigan has been found to be associated with infection by *Alternaria*. Four different species of this fungus have been isolated from seed of low germination. Some of this infection takes place in the field before harvesting. Apparently some takes place after threshing and during storage, especially when seeds are stored with a relatively high moisture content. It is suggested that thorough curing of the seed followed by dry storage, is one of the most practicable control measures.

A New Electrical Resistance Thermometer for Soils

BOUYOUCOS, G. J.

Soil Science. 63 (4): 291-298. 1947. [*Journal Article 836 (n. s.) from the Michigan Agricultural Experiment Station*]

A new liquid electrical resistance thermometer has been developed for measuring soil temperature. It has a range from about −20° to about 132° F. The liquid is contained in a glass vial fitted with platinum electrodes. The electrodes are connected to wire leads of any desired length, and the joints are permanently insulated with a special compound. The electrical resistance rises with the decrease of temperature. The electrical resistance is measured in a special Wheatstone bridge that has a range from 0 to 5,000,000 ohms. The thermometer is simple, convenient, and reliable for measuring the soil temperature at various depths.

Pullorum Disease Studies in Turkeys. I. Antibody Production Following Intravenous and Oral Infection, Relative Value of Tube and Whole-Blood Plate Agglutination Tests, Pen Contagion and Duration of Carrier State

CORPRON, R., BIVINS, J. A., AND STAFSETH, H. J.

Poultry Science. 26 (4): 340-350. 1947. [*Journal Article 849 (n. s.) from the Michigan Agricultural Experiment Station*]

This work was undertaken with the hope of supplying answers to the following questions: (1) How soon after intravenous and oral administration of living *Salmonella pullorum* cultures can antibodies be detected? (2) How much does the antibody titer vary during the course of infection? (3) How long does appreciable antibody production continue? (4) What is the relative value of the standard tube and the whole-blood plate agglutination tests? (5) Does pullorum disease spread among adult turkeys by pen contact and (6) How long may the pullorum carrier state continue? The results were as follows: Agglutinins were

detected by the tube test 3 days after intravenous injection of *S. pullorum* but not until 5 days with the whole-blood antigen. The maximum titers of intravenously injected and orally infected birds occurred on about the ninth day, after which the titer decreased in fluctuating descent. The tube agglutination test was found to be more sensitive and more consistent in reaction than the whole-blood plate agglutination test for the detection of agglutinins in the serum of turkeys infected with *S. pullorum*. The tube test gave positive reactions earlier, and, after the height of the titer had passed, revealed positive sera which were negative to the whole-blood antigens. The K47 antigen (BAI experimental) was a little more than half as effective in detecting birds of low titer or in the early and late stages of infection as was the tube test. Comparing the results of the plate test (antigen K47) with those of the 1/25 serum-antigen dilution of the tube test, the authors found that 220 tests agreed and 71 or 24.4 percent disagreed. Similarly, comparing the results of the plate test and the 1/100 dilution of the tube test, 250 tests agreed and 41 or 14 percent disagreed. Throughout the 8-month investigational period, zones of inhibition were observed in the tubes containing the greatest concentrations of sera from infected birds. These were not eliminated by increasing the concentration of antigen three-fold nor by heating the sera for varying lengths of time at temperatures of 46°, 56°, and 60° C. The data suggest that some specimens of sera that give a weak or doubtful reaction in a 1/25 dilution may be positive if tested in a 1/100 dilution. At the end of the 221-day period, four of the five birds (80 percent) remaining in the intravenously infected group were found to harbor *S. pullorum*, while only three of the seven (42.85 percent) orally infected group were still found to be carriers. *S. pullorum* was frequently recovered from the duodenum pancreas section. The controls probably did not become permanently infected nor did they develop a constant, appreciable agglutination titer as a result of pen contact with infected birds. They were less susceptible to oral infection than were their flockmates originally.

Improvements in the Plaster of Paris Absorption Block Electrical Resistance Method for Measuring Soil Moisture Under Field Conditions

BOUYOUCOS, G. J. AND MICK, A. H.

Soil Science. 63 (6): 455-465. 1947. [*Journal Article 850 (n. s.) from the Michigan Agricultural Experiment Station*]

The electrical resistance technique of obtaining a continuous measure of soil moisture *in situ* under field conditions by means of a plaster of paris absorption block is discussed in the light of additional knowledge and experience gained since the inception of the method in 1940. Fundamental considerations of the characteristics of this technique reveal that for most practical purposes standard absorption blocks need not be calibrated. Resistance readings may be directly interpreted in terms of available soil water; in all soils the percentage of available water is approximately the same for any given resistance value.

The maximum longevity of absorption blocks operating continuously in the field may exceed 5 years in a relatively dry environment. A minimum life of one season is found in waterlogged organic soils.

The special resistance bridge has been improved, and a new commercial model is presented and described.

The advantages of the method are summarized.

Milk Studies. I. Some Vitamins and Trace Elements Found in the Colostrum of the Dairy Cow, Beef Cow and Swine

LUECKE, R. W., DUNCAN, C. W., AND ELY, R. E.

Archives of Biochem. 13 (2): 277-282. 1947. [*Journal Article 860 (n. s.) from the Michigan Agricultural Experiment Station*]

No marked breed difference was found in the iron, copper, and cobalt content of colostrum milk of the Jersey and Holstein dairy cow. The concentrations of these minerals in the colostrum of the beef cow were essentially the same as the values obtained for the dairy cow.

The carotene and vitamin A content of colostrum from the Jersey cow averaged 347 and 401 γ/100 ml. while the corresponding values for Holstein colostrum were 100 and 52 γ/100 ml. The concentration of these constituents in the colostrum of the beef cows were 129 and 145 γ/100 ml., whereas, swine colostrum contained only 24 and 60 γ of carotene and vitamin A/100 ml.

The colostrum of the sow is significantly lower in riboflavin and pantothenic acid, but markedly higher in nicotinic acid than either the dairy or the beef cow. The thiamine content of sow colostrum is similar to beef cow and Holstein colostrum but lower than Jersey colostrum.

Determination of Unmet Need for Medical Attention Among Michigan Farm Families

HOFFER, C. R., AND SCHULER, E. A. (IN COOPERATION WITH ROSALIE NELIGH, AND THOMAS ROBINSON, UNIVERSITY OF MICHIGAN)

Jour. Mich. St. Med. Soc. 46: 443-446. 1947. [*Journal Article 864 (n. s.) from the Michigan Agricultural Experiment Station*]

There is a lack of reasonably accurate information which will show the extent of need for medical care among rural people. Likewise, it is desirable to know to what extent such needs are being met. The present article describes first, a method and second, an experiment to determine the validity of that method, designed to measure the need for medical attention among rural people.

The essential characteristic of the method is a medical needs schedule consisting of a list of 27 questions regarding symptoms about which a physician would ordinarily ask a patient in taking a medical history. Though these symptoms were selected in cooperation with medical physicians the questions were worded so that a person without medical training, if properly instructed and supervised, could obtain the desired information. By use of appropriate symbols a record was made of the way positive symptoms were treated. Three ways are possible: (1) no treatment, or home remedies only; (2) treatment by a non-medical physician; (3) treatment by a medical physician. Because precise evaluation of this approach was lacking, it seemed wise to validate the data obtained with the medical needs schedule. Validation was accomplished by having a random sample of approximately every sixth family among the 306 families interviewed with the schedule come to a clinic to receive a medical examination. The examination was

made by a medical physician and included a chest X-ray, a blood test for syphilis, and an analysis of a specimen of urine for albumen and sugar. The results showed that in 8 out of 10 cases there was agreement regarding the need for medical attention between the findings of the medical examination and data contained in the medical needs schedule. The correspondence between the two sets of data is so close that this method can be used to establish a reasonably reliable measure of unmet needs for medical attention among farm families.

A Comparison of the Glass Electrode and Indicator Methods for Determining the pH of Organic Soils and Effect of Time, Soil-Water Ratio, and Air-Drying on Glass Electrode Results

DAVIS, J. F. AND LAWTON, K.

Jour. Amer. Soc. Agron. 39 (8): 719-723. 1947. [*Journal Article 875 (n. s.) from the Michigan Agricultural Experiment Station*]

A comparison of glass electrode and indicator methods for determining the pH of muck soil was made on 50 samples collected at random from widely scattered areas in Michigan.

Data obtained indicate a close agreement between pH readings obtained by the indicator and glass electrode methods. Owing to the high buffer capacity of the muck, factors of time elapsing between mixing the muck sample with water and subsequent recording of the pH reading, the soil-water ratios used, and air-drying of samples do not materially affect the pH reading of the sample.

An accurate pH reading of muck may be obtained with a glass electrode when a 1:1 soil-water ratio on volume basis is used and after stirring the suspension for 1 minute.

Direct Introduction of Chemical Substances Into Herbaceous Plants

FELBER, I. M.

Science. 106 (No. 2750): 251. 1947. [*Journal Article 881 (n. s.) from the Michigan Agricultural Experiment Station*]

By using a needle made of fine florist's wire, which is threaded with white mending cotton soaked in a solution of the chemical to be tested, substances can be introduced to any desired part of a plant. This new technique can be employed regardless of the shape and inclination of organs or the nature of their surface. Methods hitherto used such as placing a drop or pellet of the substance on the surface of a leaf blade, are not feasible for application to erect parts or to surfaces of repellent or impermeable character.

Since the exact amount of substance introduced by thread into tissues can be determined, the method is used in studies of the effect of different concentrations of 2,4-D and other growth regulators on plants. Furthermore, the pH of intact plant tissue can be measured in the growing plant by using threads impregnated with indicator solutions. Many other kinds of microchemical tests can be carried out directly on various organs of the living plant.

The simple device opens many new possibilities in plant research which may lead to a better understanding of the fundamental mechanism of growth.

Medical Needs of the Rural Population in Michigan

HOFFER, C. R.

Rural Sociology. 12: 162-168. 1947. [*Journal Article 882 (n. s.) from the Michigan Agricultural Experiment Station*]

A survey to determine need for medical attention among 306 scientifically selected Michigan farm families in Cheboygan, Kent and Shiawassee counties showed that 47.9 percent of the 1,219 persons included in the sample had one or more symptoms which should receive medical attention. Among the 1,219 there were 314 individuals (27.7 percent of the total) who had one or more positive symptoms and had not seen a medical physician about them. The need for medical attention increased with the age of the population and with a decline in the gross income of the family. Need in this connection was defined as the presence of one or more of a list of 27 symptoms which had been selected in cooperation with medical physicians and validated by a medical examination of a sample of the families interviewed.

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